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Vol. 80. 1932.

NEW EXOTIC SPECIES OF THE GENUS *ECNOMUS* (TRICHOPTERA)

By Martin E. Mosely.

[Read 2nd December, 1931.]

With Forty-five Text-figures.

This paper, with its descriptions of new species, is based upon a collection of Trichoptera sent to the Imperial Institute of Entomology from Natal and Sierra Leone and kindly presented by it to the British Museum. Collections in these countries have been made by correspondents of the Institute during several years, and some have been sent to Dr. Georg Ulmer for determination and description where necessary.

Dr. Ulmer has already described species of *Ecnomus* from Natal and the Congo under the names *natalensis* and *tropicus*, determining another species from Africa as *deceptor*, McL. It is evident that there is a considerable group of these species in Africa, all of which so closely resemble one another superficially that a correct appreciation of them can only be made by clearing the genitalia in K.O.H. and making a close examination under a comparatively high power.

Having adopted this course, I became aware that there were more undescribed Sierra Leone and Natal species in a collection which had not been sent to Dr. Ulmer, and, on a close examination of accessions in the British Museum and my own collections, further undescribed species were found amongst material from the Cape, the Ivory Coast, Ceylon, the Federated Malay States and the New Hebrides.

Recently, Dr. Ulmer, 1930, *Treubia*, **11** : 383–6, 426–30, has described four new species occurring in the Far East, so that with the additions in this paper the recorded species of *Ecnomus* have increased from the two known at the time of McLachlan, to a present number of twenty-six. A complete list appears at the end of this paper, and it will be noted that so far no species have been described from the American continent.

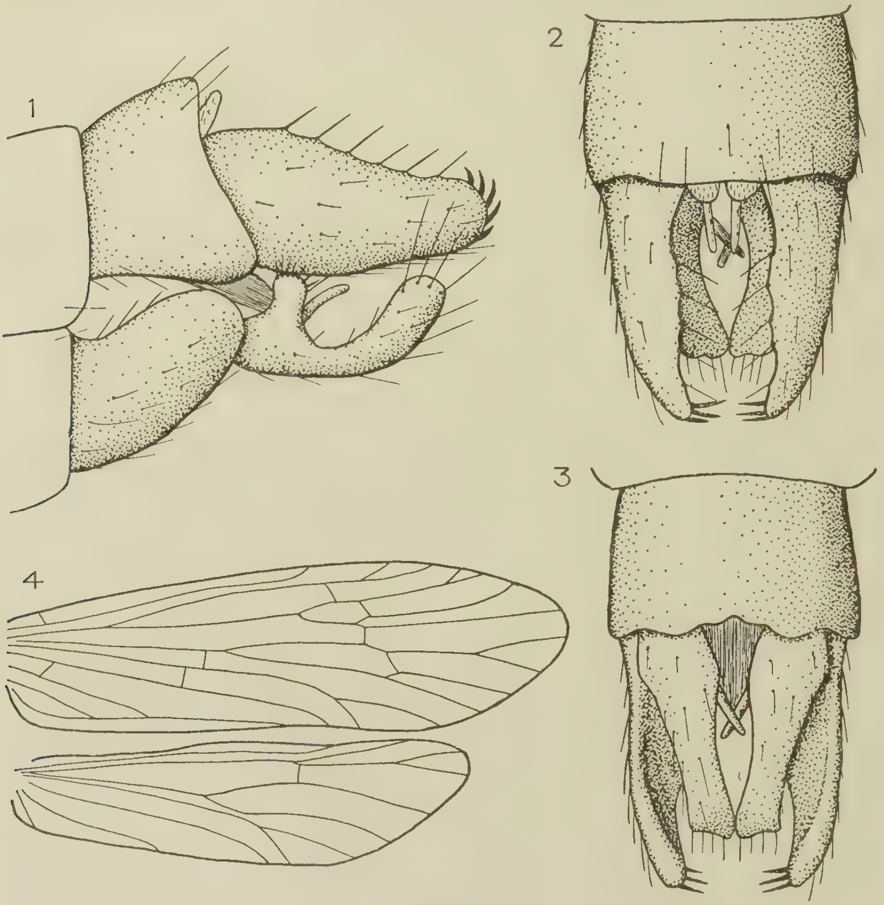
I am indebted to M. Antoine Ball, who kindly sent for my inspection examples of *E. tropicus*, Ulm., from the Brussels Museum.

The figures in this paper have been drawn by Mr. D. E. Kimmins.

Ecnomus hendersoni, sp. n. (Figs. 1–4.)

The specimens were collected in fluid. Their general appearance is probably similar to that of *E. tenellus*, Ramb.

Genitalia ♂. The tenth segment, in the type, considerably protruded, dorsal margin rather straight; from the side, tenth tergite broad at the base but broader still at the apex which is obliquely truncate; tenth sternite broad at both base and apex, inclining upward, partly separated from the tergite by a deep excision, ventral margin sinuous; at the centre of the dorsal margin are two very lightly chitinised plates which seem to be connected with the process described as the upper penis-cover. Superior appendages from above, rather broad at the base tapering to narrowish apices inclining slightly inward, inner margins serrate; from side, rather broad at the base, inner surfaces at the apices each armed with a few strong teeth. Inferior appendages from beneath, rather long, constricted towards the centre and broadening towards the apices which are truncate and somewhat sinuate; seen from the side there is a clavate process along the upper margin towards the base, then a deep wide excision towards the rounded apex which is slightly broadened and directed upward; attached to the inner sides of each appendage towards the base is a narrow,



Figs. 1–4.—*Ecnomus hendersoni*, sp. n. ♂. 1 genitalia lateral, 2 dorsal, 3 ventral, 4 wings.

pointed process, curving upwards; in the type, seen from dorsal and ventral aspects, these processes cross each other. Upper penis-cover consists of two nearly parallel transparent spines, which from the side are rather long, directed downwards, apex slightly dilated, only visible in balsam preparation; penis strongly chitinous, curving downwards; on each side are strongly chitinised penis-sheaths.

Length of anterior wing, 3 mm.

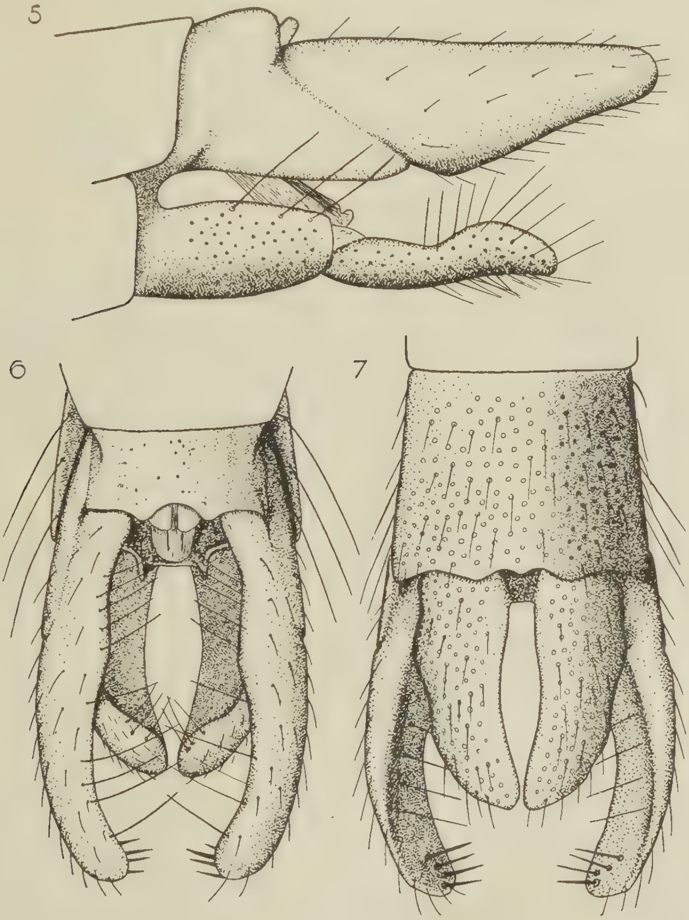
Taiping, PERAK, F.M.S., iv.1912 (*John Henderson*).

Type ♂ is a balsam preparation in the author's collection; paratype ♂ in the British Museum Collection.

I have pleasure in dedicating this species to the collector, Mr. John Henderson.

Ecnomus digitatus, sp. n. (Figs. 5–7.)

The single male example was collected in fluid. It probably resembles *E. tenellus*, Ramb., in its general appearance.



FIGS. 5–7.—*Ecnomus digitatus*, sp. n. ♂. 5 genitalia lateral, 6 dorsal, 7 ventral.

Genitalia ♂. From the side, the tenth tergite is triangular with a long base, upper angle slightly rounded; the tenth sternite slightly shorter than the tergite with a very punctate surface; from above, centre of tergite widely excised with the membranous upper part of the upper penis-cover appearing in centre of excision. Superior appendages seem to be welded to the tenth tergite and it is very difficult to follow their line of juncture. From above they are long and finger-shaped, curving inward, with slight angular projections towards the centre of their inner margins; apices rounded, with three or four strong spines on the inner surfaces, other long bristles along the inner margins; from the side, they are triangular, with the longest side on top, lower angle obtuse, upper penis-cover hidden by the superior appendages, but in a balsam preparation, they can be made out from the side as a pair of slender processes, sloping downward and armed at their apices with groups of bristles; penis from above, scarcely visible, apex rounded, with two very short penis-sheaths (?) lying on its upper surface; penis from the side, arching downward. Inferior appendages from beneath not so long as superior, broad at the base narrowing to blunt apices inclining towards each other. They are united at the base by a strongly chitinised internal ridge; from the side, they are narrow at the base, upper margin sinuous, with a slight dilatation before the obliquely truncated apex.

Length of anterior wing, 4 mm.

R. Kinta, Ipoh, F.M.S., xi.1913 (*John Henderson*).
Type ♂ is a balsam preparation in the author's collection.

Ecnomus crepidulus, sp. n. (Figs. 8–10.)

The specimen was collected in fluid; its general appearance is probably similar to that of *E. tenellus*, Ramb.

Genitalia ♂. Tergite of the tenth segment almost separated from the sternite by a deep excision; from the side, broad, with concave outer margin; sternite from the side, broader at the apex than at the base with convex outer margin, practically of the same length as the tergite. Upper portion of upper penis-cover showing at the centre of the dorsal margin as two rounded plates. Superior appendages from above, long; centre portion slightly dilated; inner margin serrate and carrying long, spine-like bristles and four or five strong teeth on the inner surface at the apex; from the side they are bluntly triangular as in *digitatus*, with the longest side of the triangle on top. Inferior appendages from above and also from beneath, somewhat resembling the apex of a pair of tongs; from the side resembling a lady's slipper, heel and sole upwards; the heel portion carries strong bristles; from beneath, this portion shows as a lateral swelling towards the base along the outer margin; penis arching downward, no visible sheaths. Upper penis-cover, only visible in a cleared balsam preparation, seen from the side, consists of two short processes, apices of which are armed with bristles.

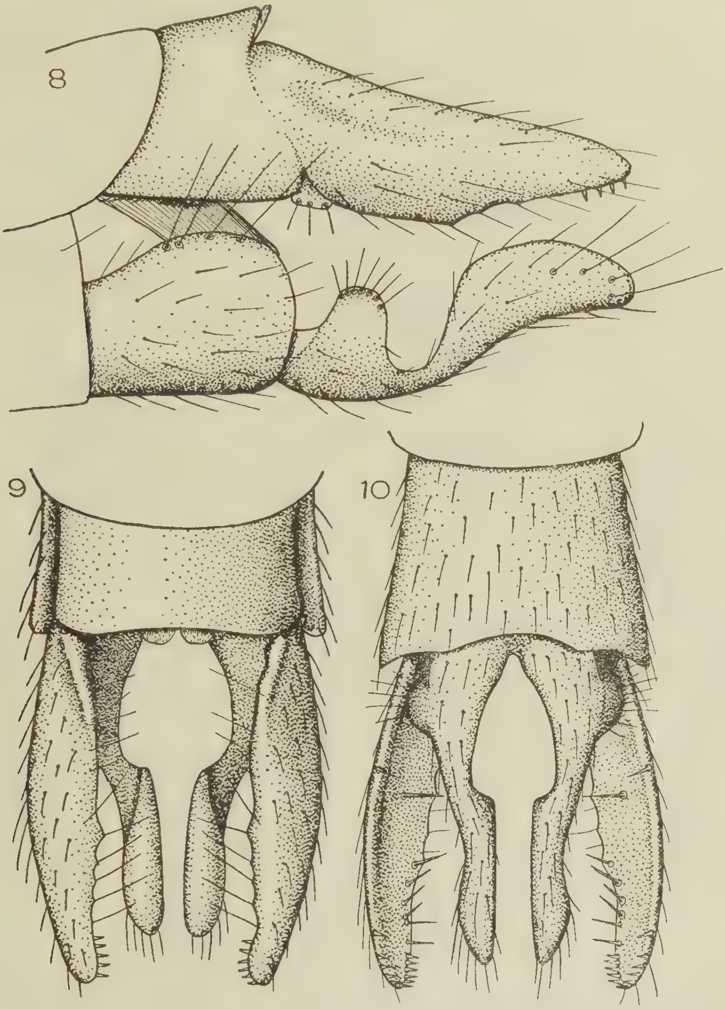
Length of anterior wing, 3·5 mm.

Lahat, F.M.S., 1926 (*John Henderson*).
Type ♂ is a balsam preparation in the author's collection.

Ecnomus forcipatus, sp. n. (Figs. 11–13.)

The only examples of this species, two in number, were collected in fluid and subsequently mounted in balsam. Their general appearance is probably similar to *E. tenellus*, Ramb.

Genitalia ♂. Dorsal margin of tenth segment slightly rounded; from the side, tenth sternite quadrangular and projecting beyond the tenth tergite; from above there are two very lightly chitinised plates towards the centre of the margin of the segment, forming the upper portion of the upper penis-cover. Superior appendages each very long and curved, somewhat slender, apex armed internally with a cluster of very long black spines; from the side, appendage is slightly dilated at the base and again at the apex. Inferior appendages forcipate with acute apices; from above, a small rounded process can be seen towards the base arising from the upper margin and directed inward; there is also a broad, angular projection beneath it arising from the inner and lower margin; from the side, the upper process appears as a small fork directed outward and upward and the lower projection as a blunt angle; the remainder of the process, finger-shaped, directed slightly upward. From beneath base of the appendage narrow then dilating inwardly to form the angular projection, then curving widely and deeply to the pointed apex. Arising, probably, from the margin of the last dorsal segment is a pair of processes which from the side are short and slender, each armed on the upper surface with a group of strong hairs and lying beneath and along the superior appendage. These probably form the upper penis-cover; penis-sheaths not visible from the side except in a balsam preparation, very broad, apices truncate and somewhat dilated; from above they appear as two conical membranous projections,



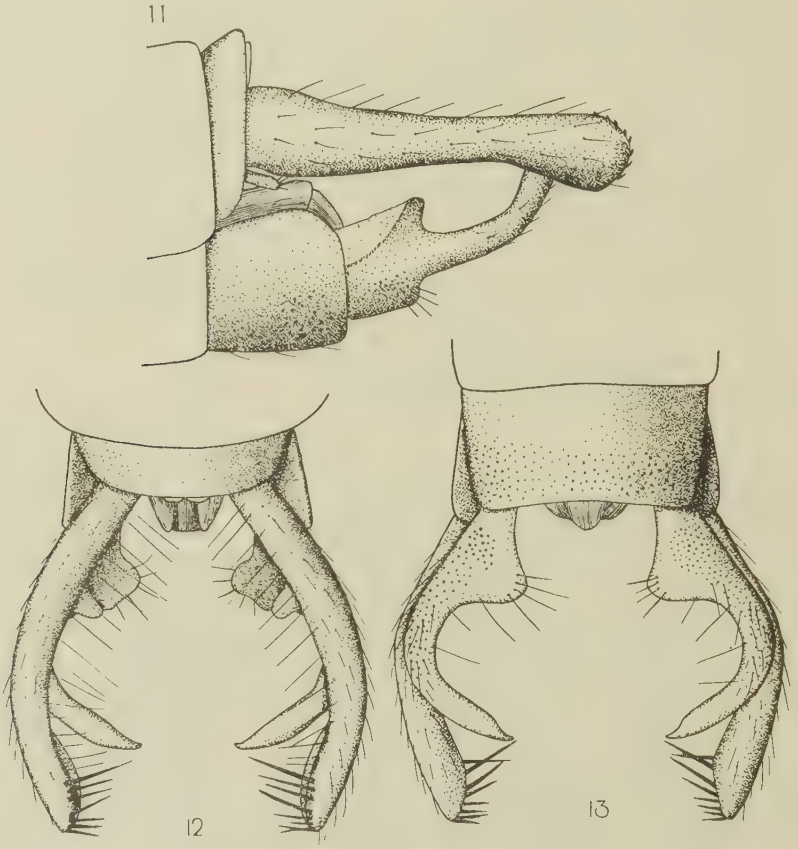
FIGS. 8–10.—*Ecnomus crepidulus*, sp. n. ♂. 8 genitalia lateral, 9 dorsal, 10 ventral.

lying between the superior appendages. Penis very obscure scarcely extending beyond the sheaths.

Length of anterior wing, 4 mm.

Taiping, PERAK, F.M.S., iv.1912 (*John Henderson*).

Type ♂ is a balsam preparation in the author's collection; paratype ♂ in British Museum Collection.



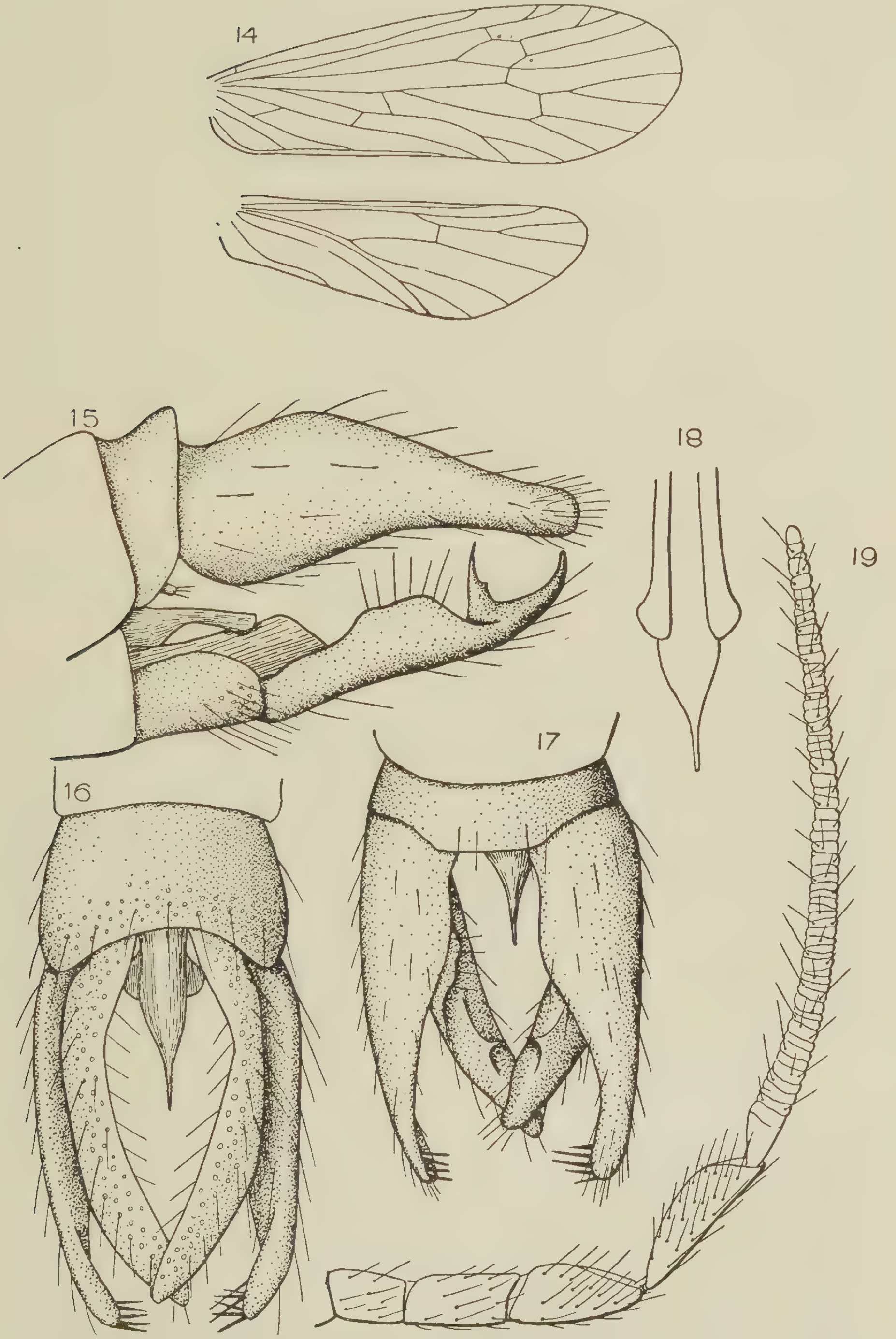
FIGS. 11–13.—*Ecnomus forcipatus*, sp. n. ♂. 11 genitalia lateral, 12 dorsal, 13 ventral.

Ecnomus (?) **atratus,** sp. n. (Figs. 14–19.)

I have some doubt as to whether this species is rightly placed in *Ecnomus*; its general appearance differs strikingly from that of all the other known species, the insect being black, without the irrorations of the anterior wing-vestiture which is the usual feature in the genus. Moreover, in the single ♀ before me, the dilatation of the median tibia is not very obvious.

It may be that with the discovery of more related material the creation of a new genus will become desirable.

Head dull fuscous clothed with black hairs; oculi black; antennae and palpi fuscous. *Wings* black, clothed sparingly with black hairs. *Legs* fuscous. *Abdomen* dark fuscous above, paler beneath, genitalia dull ochraceous. *Genitalia* ♂. Margin of last dorsal segment



FIGS. 14–19.—*Ecnomus atratus*, sp. n. ♂. 14 wings, 15 genitalia lateral, 16 ventral, 17 dorsal, 18 penis and sheaths from above, 19 maxillary palpus.

from above, rounded; from the side, the tergite is separated from the sternite by an excision; lower margin of the tergite sloping back towards its base; sternite from the side, rounded; from beneath, broad, with apical margin widely excised. Superior appendages from above, very long, rather broad at the base, inner margins parallel with each other for a short distance towards the base, then curving outwards in a slightly concave sweep to the narrow apices which are internally lined with strong spines, outer margins parallel. From the side, broad at the base, upper margin sloping downward at about the middle to form an obtuse angle, lower margin sinuate. Upper penis-cover takes the form of a pair of very short processes, apices armed with bristles; penis from above broad at base, narrowing to a long slender spine; from the side, broad, upper margin sharply elbowed downward before the apex; penis-sheaths from above, long, strongly chitinised, apices clavate; from the side, upper margin straight, lower concave. Inferior appendages from above long, rather slender, upper margins towards the centre turning inwards to make shallow shelves, a sharp stout spine arising from a ridge on upper surface towards the apex, directed upward; from the side, the appendage is narrow at the base, dilating for about three-quarters of its length, then the upper margin slopes downward to an acute upturned apex; from beneath, the appendages are long, rather narrow and incurved.

♀. Tibia of intermediate leg scarcely dilated. Ovipositor crushed in the single example.

Length of anterior wing, ♂ 3·5 mm.

Length of anterior wing, ♀ 4 mm.

NEW HEBRIDES, Erromanga, Man-o'-War N.C., 1.ix.1930 (*L. E. Cheesman*).

Type ♂ is a balsam preparation; paratypes 6 ♂♂, 1 ♀ all in the British Museum Collection.

Ecnomus ceylanicus, sp. n. (Figs. 20–22.)

General appearance as in *E. tenellus*, Ramb.

Genitalia ♂. Margin of tenth segment abruptly produced in the centre to a truncated apex; from the side, tenth sternite somewhat quadrangular and projecting beyond the tenth tergite; superior appendages short, pear-shaped, broad at base, each with a group of very thick black spines towards the apex on the inner surface; from the side gradually dilating to a broad truncated apex. Upper penis-cover, only visible from the side, in the form of a pair of short, backward curving processes armed with long hairs at tips; penis rather broad with a small excision at the apex; inferior appendages from above, longer than superior, much dilated at the base along the inner margin, then narrowing to a constricted neck, finally at the apices, twisted upward and inward so that the appendages have the appearance of a pair of birds facing each other; from the side, apices are turned upward in blunt hooks, the inner surfaces lined with a brush of very short blunt spines.

Length of anterior wing, 4 mm.

Type ♂ (abdomen mounted in balsam), Ceylon.

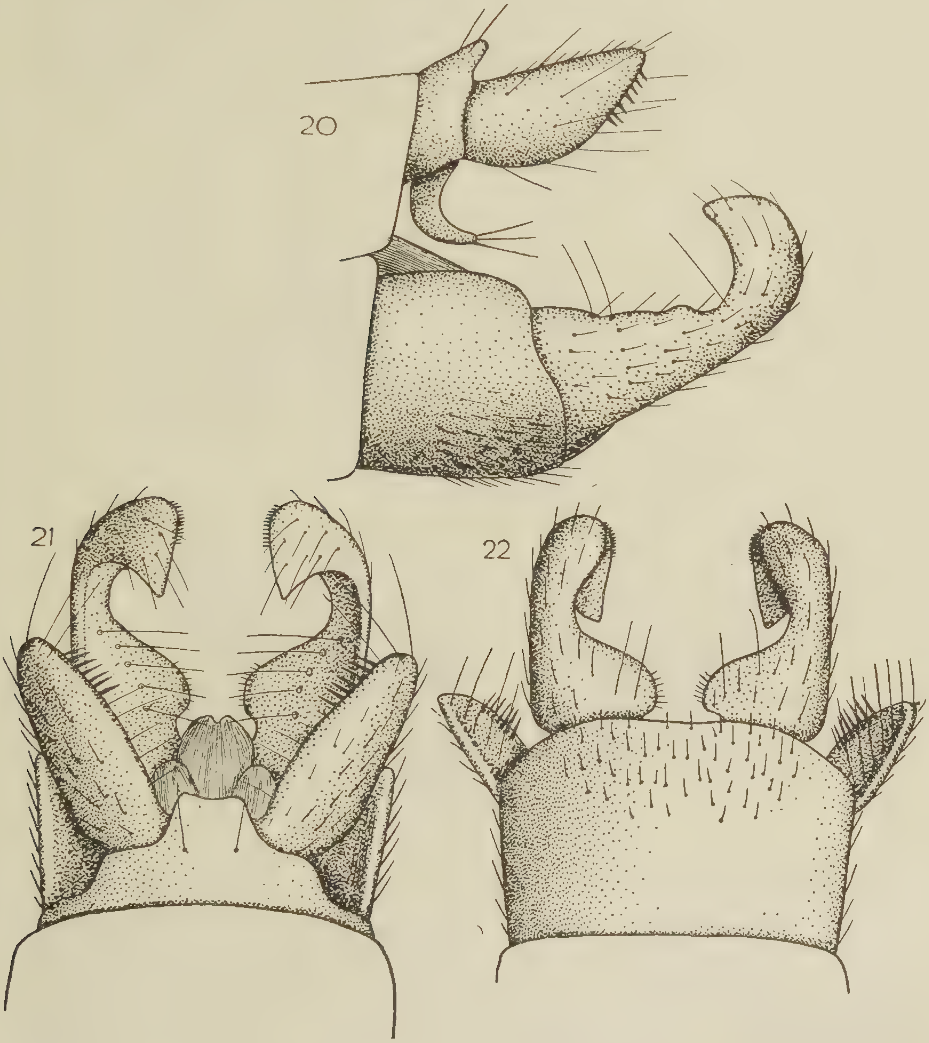
Paratypes 2 ♀♀ and 3 examples in poor condition, abdomens missing, CEYLON. 1 ♀, Weligama, 7.i.1908 (*T. B. Fletcher*), 1 ♂, Peradeniya (*J. C. Fryer*), iv.1911, 1 ♀ Peradeniya (*J. C. Fryer*), ii.1911.

All in the British Museum Collection.

Ecnomus deceptor, McL.

This species was described by McLachlan from Portuguese and Belgian material. According to Lestage the Belgian examples were in the Brussels Museum, but they no longer appear to be there. McLachlan's types are in private hands and are not accessible. From time to time the species has been recorded from Central and West Africa, the determinations being made, not by comparison with the type, but from McLachlan's description and figures.

It will be seen in this paper on the genus, that there are a large number of African species many of which could be made to agree with McLachlan's rather sketchy figures. It is more than doubtful whether any of them are the true *deceptor*, as it is most improbable that the species should have so wide a range.



FIGS. 20–22.—*Ecnomus ceylanicus*, sp. n. ♂. 20 genitalia lateral, 21 dorsal, 22 ventral.

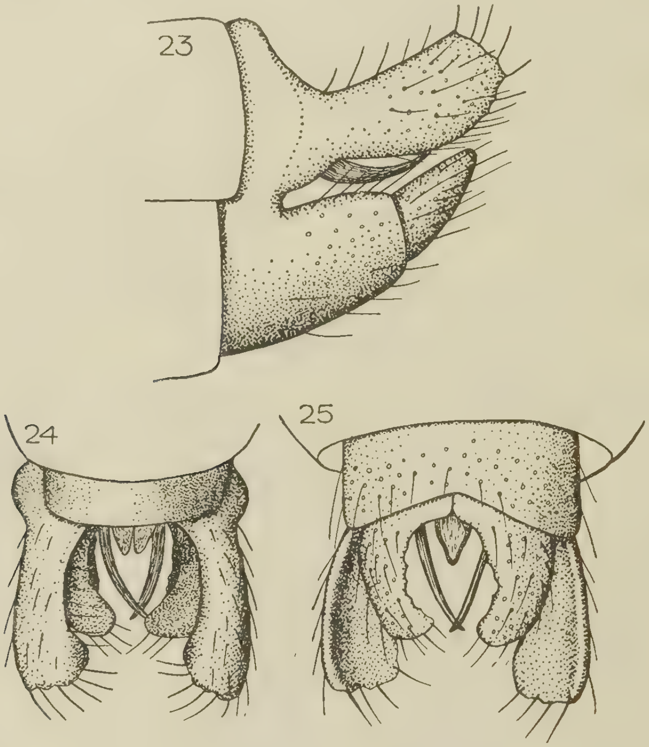
I have therefore considered it desirable to describe all these species as new, giving very full figures and descriptions of internal structures such as the upper penis-cover, penis and sheaths, from which good specific characters can be obtained.

The species described below as *Ecnomus ulmeri*, sp. n., is that which Ulmer records as *E. deceptor*, from Sierra Leone, in 1931, Deuts. ent. Z., **1931 :** 11, and is probably not the same as the examples in the Berlin Museum recorded in 1912, Deuts. Zentral-Afrika Exp., 1907–8, **4**: 91–2.

Ecnomus curtus, sp. n. (Figs. 23–25.)

General appearance much as that of *E. tenellus*, Ramb., but wings rather darker in colour.

Genitalia ♂. Superior appendages welded to the tenth tergite; from the side, constricted towards the base, dilating towards the apex which has a serrate margin; from beneath, broad, apices truncate; from above, outer margins nearly parallel, inner margins concave with slight dilatations towards the truncate apices and there are also slight dilatations on the outer margins at the base. There is a small wart, armed with bristles on the inner surface of each appendage. Tenth segment slightly withdrawn within the ninth, sternite projecting beyond the indistinct edge of the tergite, quadrilateral in shape. Inferior appendages, from the side, very short, stout at base, bluntly conical; from beneath, shorter than the superior, very stout, curving inwards. Upper penis-cover in the form of two spines; from the side, blunt at the base, curving like the tusks of an elephant; from above, apices crossing each other; upper portion of the cover appearing from above as a pair of membranous plates projecting beyond the centre of the dorsal margin. Penis from beneath, broad at the base, narrowing to a rounded apex; from the side, curving downward.



Figs. 23–25.—*Ecnomus curtus*, sp. n. ♂. 23 genitalia lateral, 24 dorsal, 25 ventral.

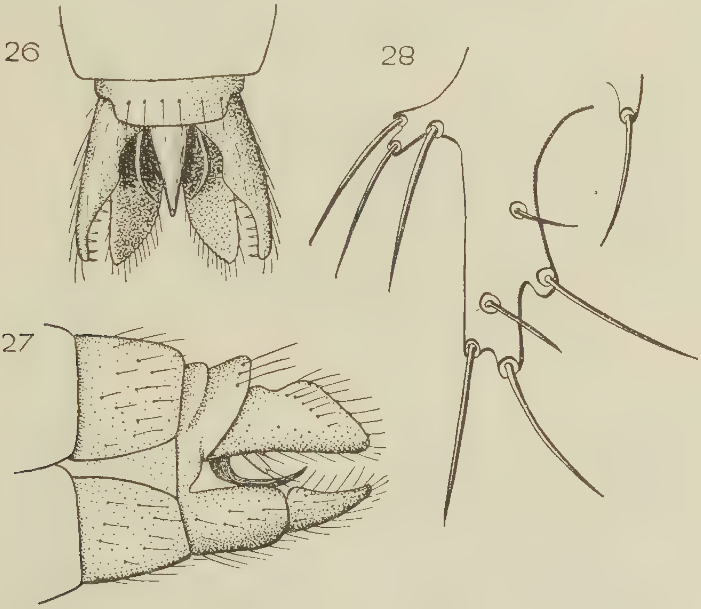
Length of anterior wing, 4 mm.

Ivory Coast, vii.1908 (*Meyer*).

Type ♂ and paratypes ♂ and ♀ in the British Museum Collection.

Ecnomus complex, sp. n. (Figs. 26–28.)

Head light fuscous, frons covered with silvery hairs, warts on the vertex with fuscous hairs; antennae ochraceous annulated with fuscous; palpi fuscous. *Wings* similar to those of *E. tenellus*, Ramb., *i.e.* light fuscous with numerous gold irrorations. *Legs* ochraceous with fuscous hairs on the upper surfaces and light ochraceous hairs beneath. *Genitalia* ♂. Sternite of tenth segment produced, forming from the side an oblong, rectangular process extending beyond the corresponding tergite; superior appendages from above, widely divergent, dilated towards the base, inner margins curving in a sinuous sweep to the narrow rounded apices, inner surfaces carrying strong hairs or spines; from the side, they terminate in a wide truncate apex. Penis from above wide at the base narrowing to an acute point, from the side terminating in a strong down-curved hook; inferior appendages from above wide at the base, divergent, inner margins curving in convex sweeps to the pointed apices; from the side, much narrower than the superior, upper margins slightly concave, bases rather wide, apices acute; attached to the tenth tergite and nearly hidden by the superior appendages is a pair of many-branched processes, somewhat resembling stick-coral in form, each branch carrying a few hairs at its apex; at its base are two slender spines, curving inwards towards the penis from above, and downward and upward from the side, the whole no doubt forming an upper penis-cover; the apex of the process can be seen in fig. 27.



FIGS. 26–28.—*Ecnomus complex*, sp. n. ♂. 26 genitalia dorsal, 27 lateral, 28 upper penis-cover from the side, much enlarged.

Length of anterior wing, 4 mm.

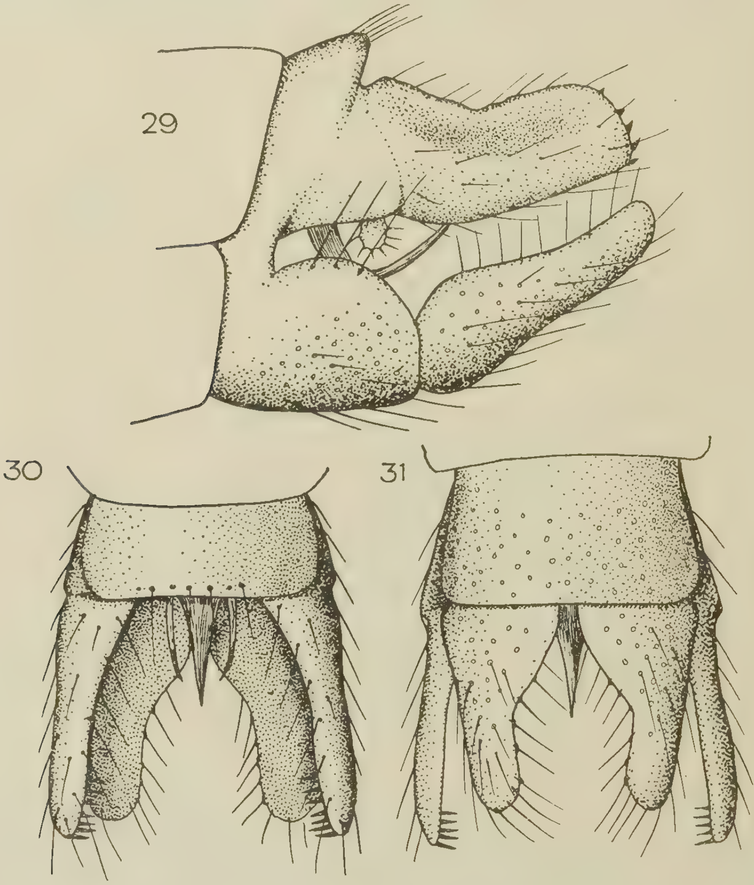
SIERRA LEONE, Njala, 21.viii.1930, 27.viii.1930 (*E. Hargreaves*), 22.x.1930.

Type ♂ (abdomen in balsam) dated 21.viii.1930, and 2 paratypes ♂ in the collection of the British Museum.

Ecnomus similis, sp. n. (Figs. 29–31.)

General appearance slightly darker than in *Ecnomus tenellus*, Ramb. Anterior wings with pale yellow irrorations on greyish-brown ground. This species very closely resembles *E. complex.*

Genitalia ♂. Tenth tergite from the side divided from the sternite by a deep excision, lower margin somewhat produced, outer margin sinuous; sternite only slightly longer than the tergite, upper margin convex, apex slightly narrower than the base. Superior appendages apparently welded to the tergite, from the side rather long, reniform; from above tapering to acute apices; upper penis-cover consists of a pair of membranous, clavate processes, extremities armed with long hairs, differing from those of *complex* which are many branched; attached to the base are two long spines which from the side descend and then curve upward; from above, slender and curving slightly inward. Inferior appendages from the side, long, pear-shaped with narrow rounded apices; from beneath, broad at base, inner margins sloping outwards rather abruptly from the base and then straightening out towards the rounded apices. Penis from above broad at base tapering to a fine down-curved point.



Figs. 29–31.—*Ecnomus similis*, sp. n. ♂. 29 genitalia lateral, 30 dorsal, 31 ventral.

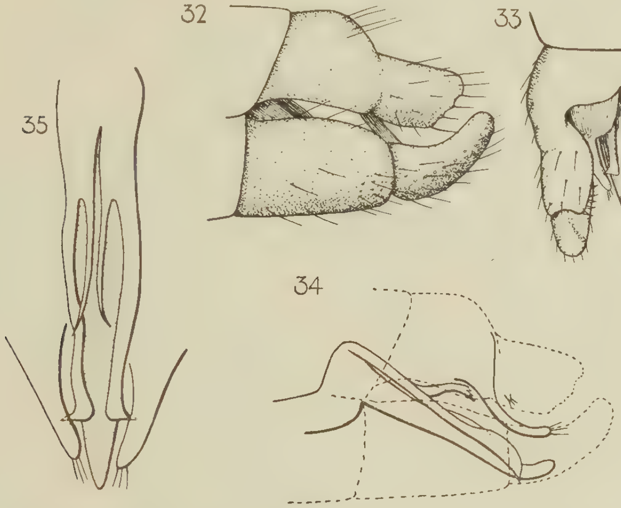
Length of anterior wing, 4 mm.

S. Africa, Cape Province, Ceres, ii.1925 (*R. E. Turner*).
Type ♂ in the British Museum Collection.

Ecnomus africanus, sp. n. (Figs. 32–35.)

The general appearance of this species is similar to that of *E. tenellus*, Ramb.

Genitalia ♂. Last dorsal segment from above, deeply excised, produced at the sides in long processes; in the excision can be seen the nearly square bases of the two processes of the upper penis-cover. From the side the last tergite, which is broad with a rounded apex, is divided from its sternite by a very long narrow excision; the sternite, slightly longer than the tergite, is also broad and somewhat rectangular. The superior appendage, partly fused to the tergite, from the side, short and rectangular, apical margin sloping forward and downward, inner apical surface armed with strong teeth; from above, apical margins shallowly excised; there is a small wart on each inner surface, carrying a few bristles. Upper penis-cover, from above, in the form of two tapering processes arising from nearly square bases, apices carrying a few bristles; from the side, curving backward in a concave sweep; beneath these can be seen two penis-sheaths which, from above, terminate in clavate apices with acute points directed outwards, giving the appearance of birds' heads; the bases of these sheaths are forked, the upper branches forming two slender processes with a deep excision between their bases; from the side the sheaths terminate in clavate apices directed downwards, and the basal forks are short, sinuate, with blunt serrated apices. Penis from above long and stout, apex acute; from the side, apex directed slightly upward. Inferior appendages from the side, slightly longer than the superior appendages, stout at the base, only slightly narrower at the apex, curving slightly upward.



Figs. 32–35.—*Ecnomus africanus*, sp. n. ♂. 32 genitalia lateral, 33 dorsal, 34 lateral to show upper penis-cover, penis-sheaths, etc., 35 penis, penis-sheaths and upper penis-cover from above.

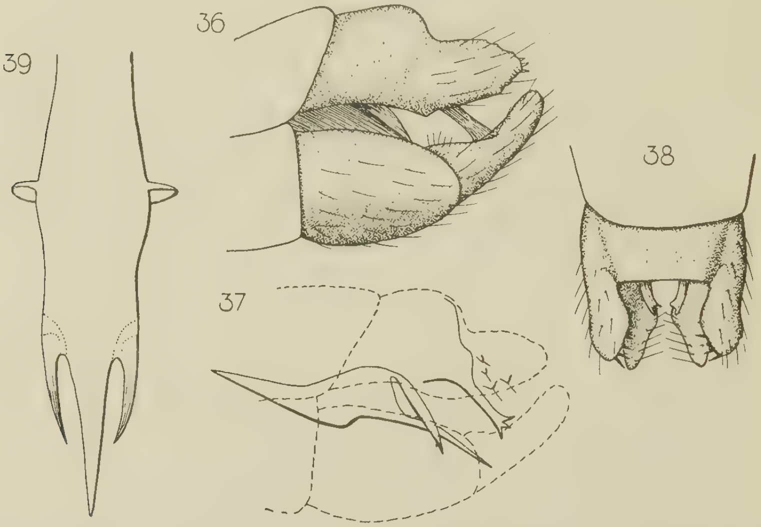
Length of anterior wing, 3 mm.

Sierra Leone, Njala, 23.x.30 (*E. Hargreaves*).
Type ♂ (abdomen in balsam) in the British Museum Collection.

Ecnomus ulmeri, sp. n. (Figs. 36–39.)

General appearance is similar to that of *E. tenellus*, Ramb.

Genitalia ♂. Last dorsal segment from above somewhat raised and narrowing slightly to a truncate apex; from the side, the tergite is separated from the sternite by a narrow excision. The superior appendages are welded to the tergite and, from the side, it is difficult to say exactly where the line of juncture is situated. The sternite, from the side, is wide with upper and lower margins convex, apex rounded. Superior appendages from above, wide, apices acute, inner surfaces, particularly at the apices, carrying strong teeth; from the side, margins serrate, four warts armed with bristles on the inner surface of each appendage. Upper penis-cover in the form of a pair of processes which from above are slightly incurved, apices furcate; from the side they are wide at the base, constricted in the centre and widening to trifurcate apices. Penis from the side, widening towards the middle, the upper margin with a deep shoulder at the centre so that the terminal half is a slender rod directed outward and downward; from above towards the base are two short lateral plates extending outward; penis-sheaths from the side, arising from the upper surface of the shoulder, stout, curving downward to acute apices on each side of the penis. Inferior appendages wide at the base, narrowing rather towards the apices, upper margins each extending inward to make a narrow shelf.



Figs. 36–39.—*Ecnomus ulmeri*, sp. n. ♂. 36 genitalia lateral, 37 lateral to show penis, upper penis-cover and penis-sheaths, 38 dorsal, 39 penis and penis-sheaths from above.

Length of anterior wing, 3 mm.

Sierra Leone, Njala, 1.xi.1930 (*E. Hargreaves*).

Type ♂, with the abdomen mounted in balsam, in the British Museum Collection.

Paratypes ♂♂, Sierra Leone, Sama, 20.v.1925; Njala, 1.xi.1930.

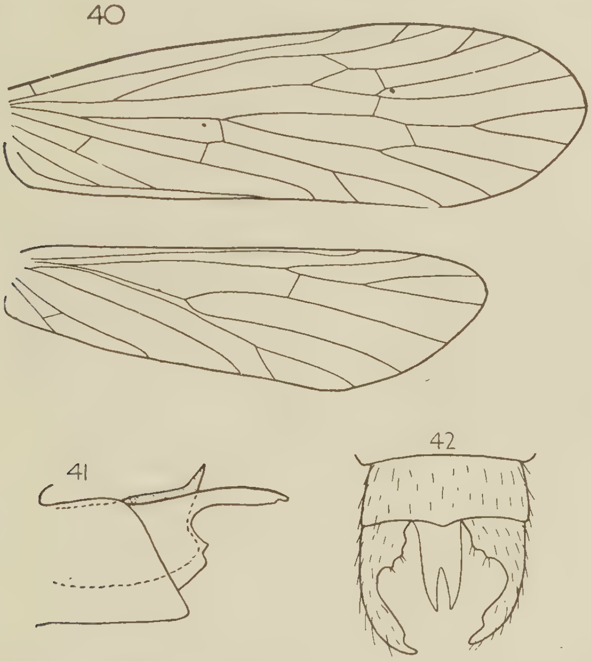
Paratypes ♀♀, Sierra Leone, Njala, 12.iv.1925 (3 examples), 24.v.1927, 21.viii.1930, 1.xi.1930, 5.xii.1930.

All in the British Museum Collection.

I have pleasure in dedicating this species to Dr. Georg Ulmer.

Ecnomus natalensis, Ulmer. (Figs. 40–42.)

The genitalia of Ulmer's type of this species, now in the British Museum Collection, have been stained and mounted in Canada balsam. As a result of the staining, certain transparent tissues have been rendered more visible, entailing a slight modification of Dr. Ulmer's figures. The inferior appendage terminates in a small finger-like apex. The penis is strongly chitinised and terminates in a pair of strong upturned spines. The ventral view shown here is drawn from a paratype. A figure of the wing-neuration has been added as it shows certain slight differences from that of the following species, *thomasseti*, which is very closely akin. Both species are separated from the others in the genus by the spur formula 2.4.4. instead of the customary 3.4.4.



Figs. 40–42.—*Ecnomus natalensis*, Ulm. 40 wings of ♂, 41 inferior appendages and penis, lateral, 42 inferior appendages and penis, ventral.

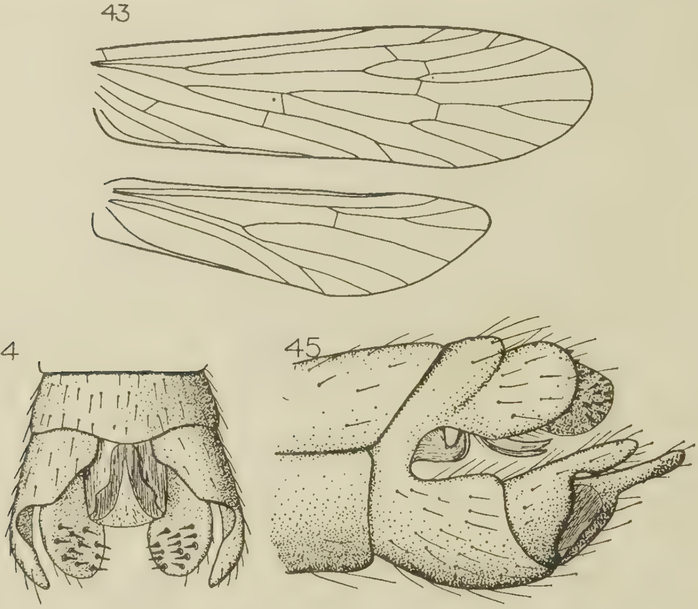
Ecnomus thomasseti, sp. n. (Figs. 43–45.)

Head light fuscous with fuscous hairs; antennae ochraceous with fuscous annulations; palpi fuscous. *Wings* light fuscous with numerous yellow-gold irrorations; posterior rather more narrow than that of *E. natalensis*. *Legs* pale ochraceous. Spurs 2.4.4. instead of the customary 3.4.4. *Genitalia* ♂. Tenth segment considerably protruded in type, sternite scoop-shaped and with a deep rounded excision between it and the tergite; superior appendages from the side, rounded, lower margin forming a blunt angle towards the base, inner surface at the apex armed with strong teeth; inferior appendages each very broad at the base, narrowing to a finger-like process, lower margin of which is deeply and widely excised at its base; penis straight and short; membranous, narrowly excised dorsally and more deeply excised ventrally; from the side there are two small upturned penis-sheaths; broad at base; hidden by the superior appendages in a direct lateral view are two stout spines curving downward and then upward, arising from the dorsal margin and forming an upper penis-cover.

Length of anterior wing, 4 mm.

NATAL, Weenen, i.1924, 2840 ft. (*H. P. Thomasset*).

Type ♂ (abdomen in balsam); paratype ♂ in the British Museum Collection.



FIGS. 43–45.—*Ecnomus thomasseti*, sp. n. ♂. 43 wings of ♂, 44 genitalia ventral, 45 lateral and slightly from beneath to show extremities of upper penis-cover and penis-sheaths.

THE DESCRIBED SPECIES OF *ECNOMUS*.*

Europe.
Ecnomus tenellus, Ramb.
,, *deceptor*, McL.
Africa.
Ecnomus deceptor, McL., doubtful.
,, *tropicus*, Ulm.
,, *complex*, sp. n.
,, *similis*, sp. n.
,, *curtus*, sp. n.
,, *natalensis*, Ulm.
,, *thomasseti*, sp. n.
,, *africanus*, sp. n.
,, *ulmeri*, sp. n.
,, sp. ♀ (Abyssinia).
Seychelles.
Ecnomus insularis, Ulm.
Ceylon.
Ecnomus ceylanicus, sp. n.
Australia.
Ecnomus continentalis, Ulm.
Philippine Isles.
Ecnomus tumidus, Ulm.
,, *viganus*, Navás.
Sumatra, Java, Malay States.
Ecnomus furcatus, Ulm.
,, *pseudotenellus*, Ulm.
,, *serratus*, Ulm.
,, *obtusus*, Ulm.
,, *hendersoni*, sp. n.
,, *forcipatus*, sp. n.
,, *crepidulus*, sp. n.
,, *digitatus*, sp. n.
New Hebrides.
Ecnomus atratus, sp. n.
China.
Ecnomus sinensis, Navás.

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* Four additional new Indian species of *Ecnomus* were received whilst this paper was in the press, and their descriptions will be published in *Stylops*, 1, No. 7.

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NEW AFRICAN ACRIDIDAE IN THE COLLECTION OF THE BRITISH MUSEUM

By N. C. E. Miller.

[Read 2nd December, 1931]

With Twenty-five Text-figures.

The species described in the present paper are from various sources in the collections of the British Museum (Nat. Hist.) and of the Imperial Institute of Entomology. All types will be deposited in the British Museum Collection.

For considerable assistance in the preparation of this paper I am indebted to Mr. B. P. Uvarov, to whom my best thanks are due.

Sub-Fam. Acridinae.

Amphicremna brevipennis, sp. n. (Fig. 1, A and B.)

Antennae longer than head and pronotum combined, triquetral in basal half, remainder moniliform and feebly compressed dorso-ventrally. Surface of head, pronotum and pleura rugose. Frontal ridge in profile almost straight; from the front margins sub-parallel to median ocellus, thence divergent to clypeus; lateral facial carinae feebly sinuate; anterior area of genae (below the eye) with an irregular sulcus from the base of the eye to the lateral angle of the clypeal suture; vertex from above broadly conical with a median carina which extends to the base of the occiput. Pronotum laterally compressed; anterior margin of disc rounded; posterior margin rotundato-angulate; median and lateral carinae distinct; median carina intersected by transverse sulcus in metazona; anterior margin of lateral lobes straight; inferior margin feebly sinuate; posterior margin feebly concave. Abdomen laterally compressed; sub-genital plate mucronate, feebly setose and projecting beyond the apex of posterior femora; supra-anal plate triangular, narrowly rounded apically and with a median longitudinal sulcus, and a depression on each side of sulcus. Posterior femora moderately slender, reaching beyond apex of elytra, with the apex of genicular lobes and of superior internal carina mucronate. Elytra moderately narrow, broadly mucronate apically. Wings moderately narrow.

Antennae, head, pronotum and pleura brown with irregular black maculation and suffusion. Head with a pale brownish ochreous stripe from the base of antennae, below the eyes and along the lower area of the genae. Lower area of lateral lobes and median area of pleura pale brownish-ochreous. Sternites brownish-ochreous. Post-ocular area of genae with two horizontal blackish-brown stripes. Abdomen ochreous, darker dorsally. Cerci dark brown. Legs dark brown, with blackish suffusion; spines on posterior tibiae tipped with black. Elytra sub-hyaline; venation dark brown. Wings broadly hyaline in costal and apical areas, remainder orange.

Total length	23·0 mm.
Pronotum	3·5 mm.
Elytra	7·0 mm.
Posterior femora	12·0 mm.

Described from 1 ♂ (type); Kampala, Uganda, 27.iii.31 (*G. L. R. Hancock*).

Paraparga brunnea, sp. n. (Fig. 2, A and B.)

Antennae flattened and expanded, triangular in section in basal two-thirds, remainder moniliform. Distance between the eyes equal to about two-thirds greatest width of fastigium of vertex. Frontal ridge in profile almost straight; from the front, margins parallel to median ocellus, feebly constricted below ocellus, thence divergent to clypeus; sulcate; fastigium from above broadly rounded apically, with the lateral margins feebly converging backwards. Head with a median longitudinal carina on vertex to base, and irregular carinae on each side parallel to it; lateral facial carinae sinuate.

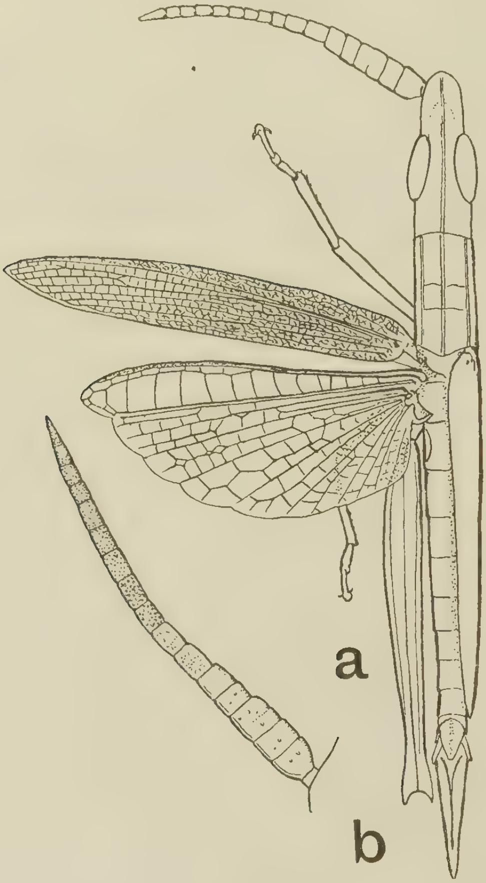

Fig. 1.—*Amphicremna brevipennis*, sp. n.
A. Whole insect from above. B. Antenna.

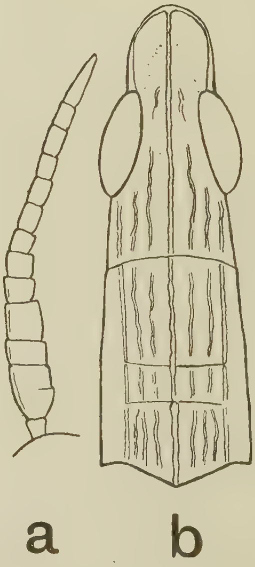

Fig. 2.—*Paraparga brunnea*, sp. n.
A. Antenna. B. Head and pronotum from above.

Anterior margin of pronotal disc rounded; posterior margin rotundato-angulate; median and lateral carinae distinct; area between these carinae with irregular parallel carinae; anterior margin of lateral lobes straight; posterior margin feebly concave; inferior margin feebly sinuate. Abdomen laterally compressed and with a strong mid-dorsal carina. Supra-anal plate ♂ triangular, with a strong median longitudinal sulcus; sub-genital plate ♂ produced, mucronate; supra-anal plate ♀ triangular with a strong median longitudinal sulcus and depressed laterally; sub-genital plate ♀ quadrate with the apical margin rounded and with a strong median projection. Elytra narrow and very narrowly rounded apically, reaching just beyond the apex of the abdomen. Internal and external superior carinae of posterior femora produced, the internal to a greater extent than external. Cerci ♂ and ♀ simple.

General coloration brown. Abdomen brownish-ochreous. Eyes light brown. Wings hyaline suffused with pale ochreous basally.

	♂	♀
Total length	23·0 mm	26·5 mm.
Pronotum	4·0 mm	4·5 mm.
Elytra	16·5 mm.	16·5 mm.
Posterior femora	12·5 mm.	14·0 mm.

Described from 1 ♂ (type) and 1 ♀; Busi R., PORTUGUESE EAST AFRICA, Dec. 1906 (*C. F. M. Swynnerton*).

Roduniella ugandae, sp. n. (Fig. 3.)

Antennae longer than head and pronotum together; dorso-ventrally compressed basally. Fastigium of vertex from above triangular. Frontal ridge in profile straight but feebly concave above median ocellus; from the front, margins arcuate between antennae, parallel to ocellus thence divergent to clypeus. Median carina of pronotum distinct, intersected by 3rd sulcus; lateral carinae almost straight and parallel in prozona, feebly arcuate in metazona; median carina in profile feebly sinuate in prozona, feebly arcuate in metazona. Anterior margin of pronotal disc almost straight; posterior margin obtuse angulate; anterior margin of lateral lobes feebly sinuate; posterior margin feebly concave; inferior margin concave in anterior half, straight in posterior half. Supra-anal plate ♂ triangular, with the apex narrowly rounded, the sides feebly sinuate, with a median longitudinal basal depression, and with the anterior half obliquely depressed laterally; sub-genital plate ♂ conical. Supra-anal plate ♀ triangular, broadly rounded apically, laterally compressed and with a median basal depression; sub-genital plate ♀ with the apical margin sinuate and with a strong mucronate projection. Elytra moderately narrow with a well-developed costal lobe.

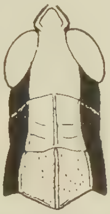

FIG. 3.—*Roduniella ugandae*, sp. n.
Head and pronotum from above.

Antennae dark brown. Eyes light brown. Head green with brownish suffusion on upper area of genae; clypeus and mandibles brownish-green. Disc of pronotum green; upper half of lateral lobes blackish or greenish-black, lower light brown. Sternites and ventral surface of abdomen ochreous. Epimera blackish; episterna light brown. Anterior and median legs brownish; internal and upper external faces of posterior femora light brown; upper external face with three broad brownish fasciae. Knees blackish-brown; posterior tibiae brown; spines whitish, tipped with dark brown. Area intercalata and area apicalis of elytra brownish, remainder green. Wings hyaline with the outer area broadly infumate.

	♂	♀
Total length	13·5 mm.	18·5 mm.
Pronotum	3·0 mm.	3·5 mm.
Elytra	12·0 mm.	13·5 mm.
Posterior femora	10·0 mm.	11·0 mm.

Type ♂. Described from 8 ♂♂ and 6 ♀♀; Entebbe, Uganda, Jan. 1913 (*C. C. Gowdey*).

Weenenia, gen. nov. (Fig. 4, A–C.)

Allied to *Lobopoma,* Karsch, but the fastigium of the vertex is shorter, more rounded anteriorly and convex. Lateral pronotal keels feebly concave; transverse sulcus well beyond the middle; lateral lobes obtusely angulate in the middle.

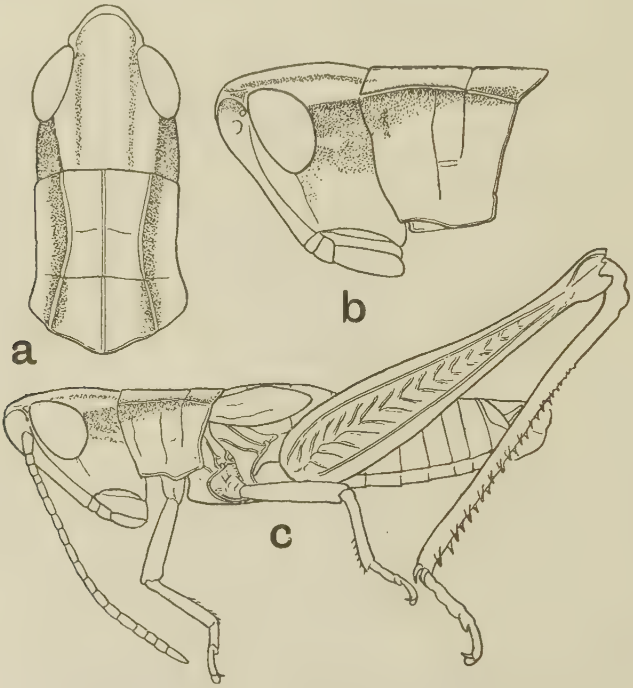

Fig. 4.—*Weenenia thomasseti,* gen. et sp. n.
A. Head and pronotum from above, ♀. B. Head and pronotum from side, ♀. C. Whole insect from side, ♂.

Weenenia thomasseti, sp. n.

Antennae dorso-ventrally compressed basally, particularly segments 3–7; in the ♂ longer, in the ♀ shorter than head and pronotum together. Distance between eyes slightly less than greatest fastigial width. Frontal ridge in profile straight in ♂, convex in ♀; from the front, margins sub-parallel to median ocellus, thence feebly divergent to clypeus; sulcate; lateral facial carinae feebly arcuate; fastigium of vertex broadly rounded. Anterior margin of pronotal disc almost straight; posterior margin obtuse angulate; disc with a strong median carina strongly intersected in metazona only; lateral carinae distinct and arcuate; anterior margin of lateral lobes straight; posterior margin concave; inferior margin with the anterior half concave and the posterior half straight; upper area of lateral lobes depressed. Supra-anal plate ♂ triangular with the apex rounded and feebly recurved; surface with a somewhat indefinite median longitudinal sulcus and a narrow median transverse sulcus; sub-genital plate ♂ conical, broadly rounded apically; supra-anal plate ♀ triangular, broadly rounded apically, smooth; sub-genital plate ♀ quadrate with the apical margin obtuse angulate. Elytra reaching just beyond the apical margin of 1st abdominal segment in ♂ and just beyond 2nd segment in ♀.

General coloration light brown. Sternites and ventral surface of abdomen pale ochreous. Head with blackish-brown suffusion by the eyes extending to base of head, and on upper area of genae. Pronotum with dark brown suffusion on upper area of lateral lobes. Antennae with blackish suffusion apically. Lower part of and external face of posterior femora pale ochreous; knees and base of posterior tibiae black; spines on posterior tibiae tipped with black. In the ♀ the suffused areas on head and pronotum are black. The metazona of pronotal disc is also suffused with black laterally.

	♂	♀
Total length	13·0 mm.	21·5 mm.
Pronotum	3·0 mm.	4·0 mm.
Elytra	3·0 mm.	5·5 mm.
Posterior femora	9·0 mm.	14·0 mm.

Described from 3 ♂♂, one of which is the type, and 4 ♀♀; M'Kolombe Mt., 5000 ft., nr. Weenen, NATAL (*H. P. Thomasset*).

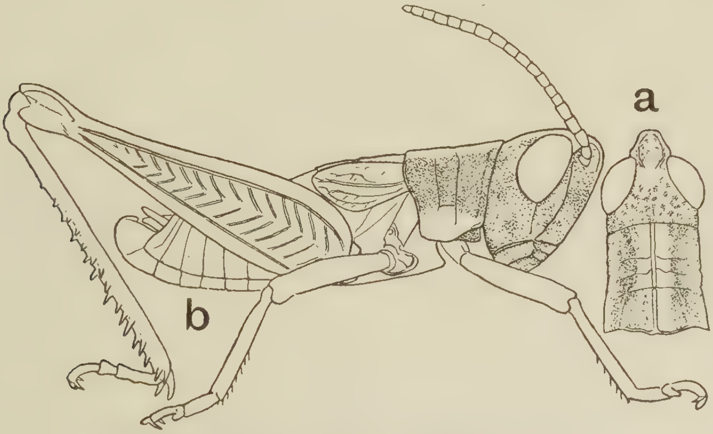

FIG. 5.—*Gymnobothroides hemipterus*, sp. n.
A. Head and pronotum from above. B. Whole insect from side, ♂.

Gymnobothroides hemipterus, sp. n. (Fig. 5, A and B.)

Antennae sub-moniliform, longer than head and pronotum, dorso-ventrally compressed in basal half. Frontal ridge in profile almost straight, from the front strongly sulcate, margins sub-parallel above and slightly constricted immediately above median ocellus, thence divergent to clypeus; lateral facial carinae arcuate. Fastigium of vertex from above ovate; surface depressed. Anterior margin of pronotal disc almost straight, posterior margin broadly rounded; median carina distinct, intersected by transverse sulcus in metazona; posterior margin of disc about twice as broad as anterior margin; anterior margin of lateral lobes straight; posterior margin feebly concave; inferior margin obtuse angulate with the anterior half feebly concave. Elytra elongate ovate, reaching just beyond apical margin of 1st abdominal segment. Supra-anal plate triangular with a strong median longitudinal sulcus. Cerci simple.

Antennae blackish. Eyes brownish-olivaceous with dark brown suffusion. Head dark brown, with irregular pale ochreous suffusion on vertex, frontal ridge and lateral facial carinae. Pronotum dark brown, or blackish-brown, with a broad pale ochreous stripe on disc and with inferior half of lateral lobes pale ochreous. Sternites and ventral surface of abdomen reddish. Anterior and median legs brownish; posterior femora reddish-brown, becoming black towards knees; posterior tibiae black basally, remainder blackish-brown. Abdomen dorsally light brown, with dark brown maculation. Elytra dark brown, light brown along inner margin.

Total length	12·5 mm.
Pronotum	2·5 mm.
Elytra	3·0 mm.
Posterior femora	8·5 mm.

Described from 2 ♂♂; nr. Weenen, M'Kolombe Mt., NATAL, 5009 ft., 30.i.1927 (*H. P. Thomasset*).

Closely resembles *G. pullus*, Karny, differing principally in its smaller size, and in having the lateral carinae of the pronotum obsolescent. The transverse sulci on the disc are indistinct and irregular in pro- and mesozona, whereas in *G. pullus* the sulcus is absent from the prozona and the sulci in the meso- and metazona converge towards the median carina.

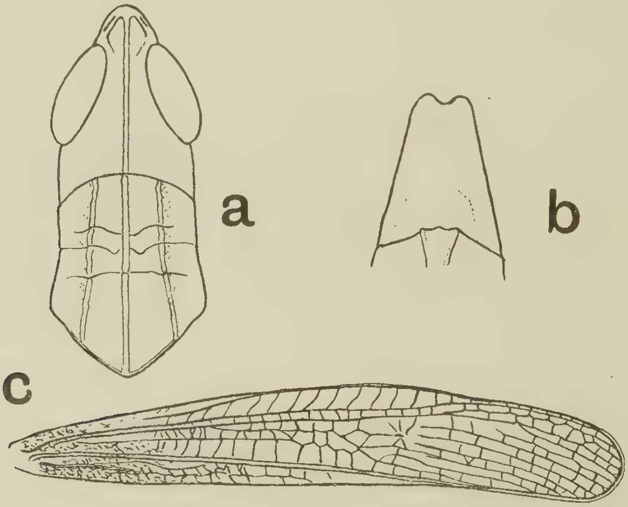

FIG. 6. *Aulacobothrus vitripennis*, sp. n.
A. Head and pronotum from above. B. Sub-genital plate, ♂. C. Elytron.

Aulacobothrus vitripennis, sp. n. (Fig. 6, A–C.)

Fastigium of vertex ovate, concave, with the margins well raised, and with a median carina which continues throughout the occiput; frontal ridge in profile almost straight; from the front, sulcate throughout, margins sub-parallel, feebly constricted above median ocellus. Antennae slightly shorter than head and pronotum combined. Distance between the eyes slightly less than greatest fastigial width. Median carina of pronotum distinct and somewhat irregular, intersected by 3rd transverse sulcus only; in profile straight in prozona, feebly sinuate in metazona; lateral carinae irregular, obliterate in metazona in ♀. Surface of pronotum rugulose punctate with a weak and irregular longitudinal sulcus just below lateral carinae. Greater part of prozona and upper half of metazona of lateral lobes almost smooth. Anterior margin of pronotal disc broadly rounded; posterior margin obtuse angulate. Supra-anal plate ♂ triangular, with the apex rounded, and with three short longitudinal depressions basally; sub-genital plate bilobate apically. Elytra exceeding the apex of posterior femora by about a fifth of their length; cross-veins in distal part of mediastinal area sub-parallel and widely separated. Supra-anal plate ♀ triangular with the apex rounded, strongly laterally and dorso-ventrally compressed.

Antennae brown with some black suffusion at base. Eyes light brown. Head and pronotum greyish-brown; head with black punctured spots, and somewhat indefinite greyish stripes on genae and vertex. Pronotum with black punctured spots, and brownish suffusion in metazona of lateral lobes, and with the lower margin of lateral lobes ochreous. Abdomen ventrally, and lower faces of posterior femora ochreous. Elytra hyaline with blackish venation, dense light brown venation in basal third, and with faint infumate spots in apical third. Wings hyaline, faintly ochreous basally and faintly infumate apically. Legs light brown.

	♂	♀
Total length	17·0 mm.	23·0 mm.
Pronotum	3·5 mm.	4·5 mm.
Elytra	15·0 mm.	17·5 mm.
Posterior femora	9·0 mm.	13·0 mm.

Described from 1 ♂ (type) and 2 ♀♀; Okahandja, S.W. AFRICA, 27.i.–2.ii.1928 (*R. E. Turner*).

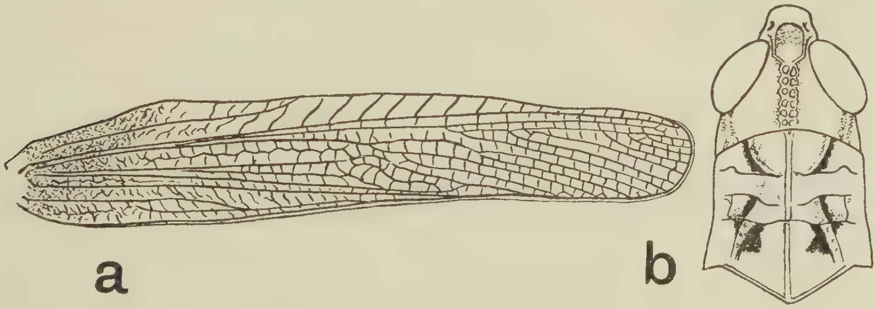

FIG. 7.—*Dnopherula marshalli*, sp. n.
A. Elytron. B. Head and pronotum from above.

Dnopherula marshalli, sp. n. (Fig. 7, A and B.)

Fastigium of vertex rounded apically; vertex with two parallel rows of irregular foveolae. Frontal ridge in profile almost straight; from the front, margins sub-parallel; surface punctate, feebly depressed around median ocellus. Temporal foveolae feeble. Lateral lobes with two deep foveolae on upper area of prozona.

Brown with two diagonal black spots on pronotum. Lateral lobes with an elongate black spot on prozona below lateral carina. Posterior femora with three transverse black fasciae on upper faces, a black spot below basal fascia and black spots on lower external carina. Posterior tibiae light brown with faint reddish suffusion apically. Spines on posterior tibiae tipped with black. Elytra with brownish suffusion at costal lobes. Wings hyaline, narrowly infumate apically.

The coloration of the ♀ is similar with these differences—the black spots are almost absent from the pronotal disc, and the black area on the lateral lobes is less defined. The brownish suffusion at the costal lobes of the elytra is more defined.

	♂	♀
Total length	13·5 mm.	20·5 mm.
Pronotum	3·0 mm.	4·0 mm.
Elytra	12·0 mm.	16·0 mm.
Posterior femora	9·5 mm.	

Described from 6 ♂♂ and 3 ♀♀; Salisbury, Mashonaland, 1908 (*G. A. K. Marshall*). Type ♂.

Dnopherula citrina, sp. n. (Fig. 8, A and B.)

Antennae feebly compressed basally, longer than head and pronotum together. Eyes with the front margin almost straight. Distance between the eyes equal to greatest fastigial width. Fastigium of vertex from above pentagonal, with the apical margin feebly rounded; deeply impressed in basal half. Frontal ridge in profile almost straight; margins parallel, obliterate below median ocellus; surface with scattered punctures; lateral facial carinae arcuate; fastigio-facial angle rounded, less than a right angle; surface of face, lower area of genae and occiput punctate. Posterior margin of pronotal disc rectangular, thickened; anterior margin broadly rounded; median carina in profile feebly arcuate in pro- and metazona; from above distinct, deeply intersected by third transverse sulcus; lateral carinae present but weak in anterior half of prozona only; surface of pronotum rugose; anterior half of prozona irregularly impressed. Elytra with the costal lobe moderately well developed, and with the cross-veins in the apical half of area mediastina sub-parallel and widely separated.

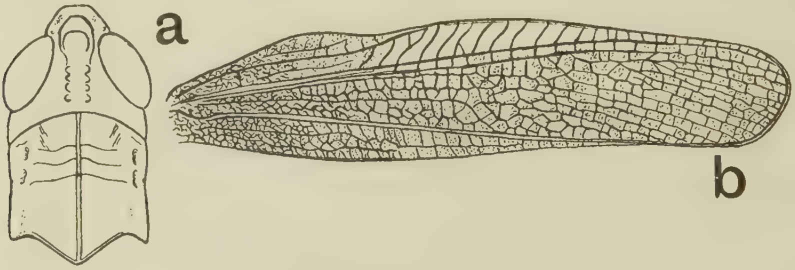

Fig. 8.—*Dnopherula citrina*, sp. n.
A. Head and pronotum from above. B. Elytron.

Antennae brown, paler or reddish-brown basally. Eyes brownish-olivaceous. Face and lower area of genae greyish-brown; upper area of genae and vertex darker. Pronotum purplish-brown; lateral lobes paler. Abdomen ochreous with reddish suffusion dorsally. Elytra with brown venation and brownish suffusion between the nervures; area on apical side of costal lobe hyaline. Wings feebly infumate apically and with a pale ochreous suffusion basally.

Total length	18·0 mm.
Pronotum	4·0 mm.
Elytra	15·5 mm.
Posterior femora	12·0 mm.

Described from two ♂♂; Mazoe, Mashonaland, Dec. 1905 (*G. A. K. Marshall*).

The following note attached to the type in the British Museum was written by Uvarov in 1922—" differs from type of *Ticra pictipes*, Bol., in less defined temporal foveolae, more rounded fastigium, coloration of elytra and hind femora."

Jasomenia cinctipes, sp. n. (Fig. 9.)

Fastigium of vertex longer than broad, narrowly rounded apically. Fastigio-facial angle slightly more than a right angle. Frontal ridge in profile feebly concave at median ocellus, sulcate throughout. Lateral facial carinae arcuate. Pronotum somewhat constricted in prozona, posterior margin of disc sinuate. Supra-anal plate with a feeble indentation on each side of apex, the lateral margins feebly concave and with the apical half strongly dorso-ventrally compressed; sub-genital plate conical, moderately setose; supra-anal plate laterally compressed and broadly rounded apically; sub-genital plate quadrate with the apical margin broadly rounded. Cerci ♂ robust, simple and curving inwards feebly.

Antennae dark brown. Eyes brown. Head olivaceous with dark brown maculation on vertex and dark brown suffusion on genae behind the eyes. Pronotum green with the upper half of lateral lobes, and a large triangular spot on metazona of disc dark brown. Pleura brownish. Sternites and ventral surface of abdomen light brownish-olivaceous. Abdomen dorsally brown. Posterior femora light brown with the lower external face brownish-ochreous, three somewhat indefinite blackish fasciae on upper faces and two brown spots on lower external carina in apical half; posterior tibiae brownish-white with the base dark brown and with a sub-median and apical brown fascia. Spines whitish tipped with dark brown. Elytra sub-hyaline with the mediastinal and anal areas green; nervures dark brown. Wings hyaline.

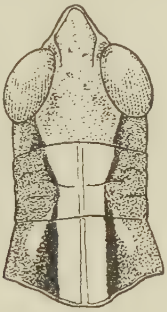

Fig. 9.—*Jasomenia cinctipes*, sp. n.
Head and pronotum from above.

	♂	♀
Total length	15·5 mm.	25·0 mm.
Pronotum	3·0 mm.	4·0 mm.
Elytra	17·0 mm.	22·5 mm.
Posterior femora	10·0 mm.	13·5 mm.

Described from 1 ♂ (type) and 6 ♀♀; Orange River Colony (*G. E. H. B. Hamilton*).

The following note by Uvarov is attached to the type in the British Museum —" differs from the type of *J. dimidiata* in fastigium more angulate in profile, eyes less prominent, more oblique, band of pronotum broader, metazona longer and more rounded, coloration of hind tibiae."

Lounsburyna fumosa, sp. n. (Fig. 10.)

Differs from *L. capensis*, Uv., in being slightly less robust, in the shape of the pronotal disc and in having the lateral facial carinae less strongly defined.

The general coloration is darker than in *L. capensis*, which also has the posterior femora narrower and more compressed laterally.

Light brown with irregular dark brown mottling. Pronotum with the lateral carinae dark brown in prozona, light brown in metazona in ♂. Vertex and genae, with black maculation. Anterior and median femora light brown with dark brown maculation apically; posterior femora light brown with four transverse dark brown fasciae on upper internal and external faces, the basal fascia somewhat indefinite.

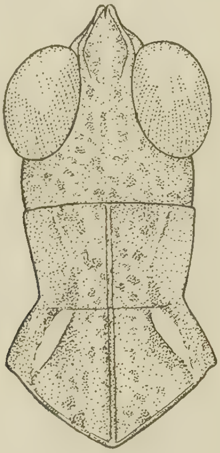

Fig. 10.—*Lounsburyna fumosa*, sp. n.
Head and pronotum from above.

	♂	♀
Total length	11·0 mm.	15·5 mm.
Pronotum	2·5 mm.	3·0 mm.
Elytra	9·0 mm.	13·0 mm.
Posterior femora	6·0 mm.	11·0 mm.

Described from 1 ♂ (type) and 1 ♀; Matjesfontein, 1–6.xi.1928 and 6–15.x.1928 (*R. E. Turner*).

Sub-Fam. Oedipodinae.

Pycnodictya flavipes, sp. n. (Fig. 11.)

Fastigium of vertex from above truncate apically; margins concave, surface rugose. Frontal ridge in profile feebly sinuate, obliterate near clypeus; surface rugose, fastigio-facial angle broadly rounded; lateral facial carinae almost straight, obliterate in lower half; surface of face and lower area of genae rugose; rest of head smooth with the exception of a small feebly rugose area on vertex; distance between the eyes slightly less than greatest fastigial width. Anterior margin of pronotal disc broadly rounded, feebly sinuate; posterior margin acute angulate with the immediate angle rounded and the sides sinuate; median carina in profile feebly arcuate with an incision at metazona; anterior and posterior margins of lateral lobes almost straight; posterior half of lower margin rounded, anterior half concave, surface of pronotum rugulose with some irregular depressed areas on lateral lobes in prozona.

Supra-anal plate ♂ flat with the apex rounded and the sides feebly constricted medially, with a median oblique carina in basal half and irregular raised areas in apical half; subgenital plate ♂ conical, with a deep median basal depression. Cerci simple.

Eyes brownish-ochreous. Genae and vertex greyish with the rugose areas suffused with pink; remainder of head pinkish. Pronotum and pleura reddish-brown; sternites and abdomen ochreous. Anterior and median legs greyish with irregular dark brown and pinkish suffusion; posterior femora greyish with the oblique ridges and upper faces brownish; inner faces dark brown; external carinae with black spots. Elytra hyaline with brown venation and very dense reticulation in basal half. Wings hyaline with the basal area pink and with a median rather narrow transverse infumate stripe.

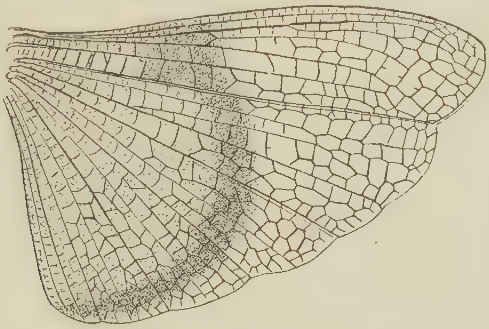

FIG. 11.—*Pycnodictya flavipes*, sp. n.
Wing.

	♂	♀
Total length	21·0 mm.	36·0 mm.
Pronotum	6·0 mm.	9·0 mm.
Elytra	22·0 mm.	31·0 mm.
Posterior femora	13·0 mm.	19·0 mm.

Described from 2 ♂♂, one of which is the type, and 9 ♀♀; PRETORIA, 1902 (*W. L. Distant*).

Acrotylus bilobatus, sp. n. (Fig. 12, A–C.)

Pronotum strongly compressed medially laterally. Median carina in profile bilobate in prozona, feebly sinuate in metazona. Prozona of disc irregularly tuberculate and rugose. Supra-anal plate ♂ triangular, with a median transverse sulcus and the margin bisinuate.

Greyish-brown. Clypeus, base of genae, and an oblique stripe from eye to clypeus light brown; face shining black; genae and vertex with irregular black suffusion. Pronotum with anterior area of lateral lobes light brown and with an irregular shining black spot in prozona.

Sternites and abdomen light brown. Anterior and median tibiae light brown with narrow black fasciae. Posterior femora light brown with irregular black suffusion which is strongest on external face. Elytra brownish and with two transverse interrupted black fasciae in basal half, and with apical half hyaline with brownish-black spots. Wings hyaline with the basal area red and with a median transverse infumate fascia.

	♂	♀
Total length	16·0 mm.	22·0 mm.
Pronotum	3·0 mm.	3·5 mm.
Elytra	16·5 mm.	20·0 mm.
Posterior femora	10·0 mm.	12·0 mm.

Described from 2 ♂♂ and 2 ♀♀; Brits, TRANSVAAL, 15.xi.1929. Type ♂.

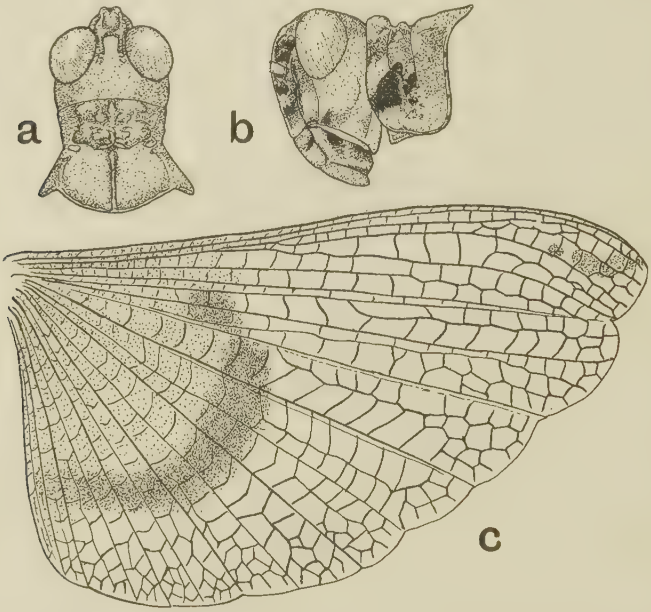

FIG. 12.—*Acrotylus bilobatus*, sp. n.
A. Head and pronotum from above. B. Head and pronotum from side. C. Wing.

Xenotettix albicans, sp. n. (Fig. 13, A–D.)

Frontal ridge with scattered punctures, impressed around ocellus, widening at ocellus, thence obliterate; in profile rounded above and feebly concave below ocellus. Fastigium of vertex feebly impressed. Eyes irregularly oval, somewhat flattened above. Distance between eyes somewhat less than half the width of an eye. Occiput strongly sloping backwards. Pronotum almost smooth; hind angle obtuse, rounded. Elytra extending beyond hind knees. Apical spine on anterior tibiae slightly shorter than basal tarsal segment; spurs of posterior tibiae feebly curved, the outer ones about two-thirds the length of the inner ones.

General coloration pinkish-white. Antennae with indefinite, narrow pale ferrugineous transverse fasciae, and the apical half suffused with pale ferrugineous. Eyes brownish-ochreous. Head with small purplish suffused spots behind and in front of the eyes. Pronotum with the metazona faintly suffused with brownish, and with suffused dark ferrugineous spots on anterior and posterior margins. Upper margin of coxal cavities on metathorax dark ferrugineous. Sternites and abdomen whitish; dorsum of abdomen suffused with blue. Ovipositor valves blackish-brown apically. Anterior femora with pale, median femora with dark ferrugineous transverse fasciae; median tibiae with black fasciae; posterior femora with a brownish median fascia on upper faces and extending but becoming indefinite to outer face, with a sub-apical dark brown fascia, and with some reddish-black spots on lower external carina; knee with some indefinite reddish-brown spots; lower external and internal faces suffused with blue; spines on posterior tibiae tipped with brown; internal genicular lobes and base of posterior tibiae (internal face) with purplish indefinite spot. Elytra pale brownish-ochreous with ferruginous and whitish spots and dark brown suffusion at costal lobe. Wings faintly blue with blue venation, except in apical area where whitish.

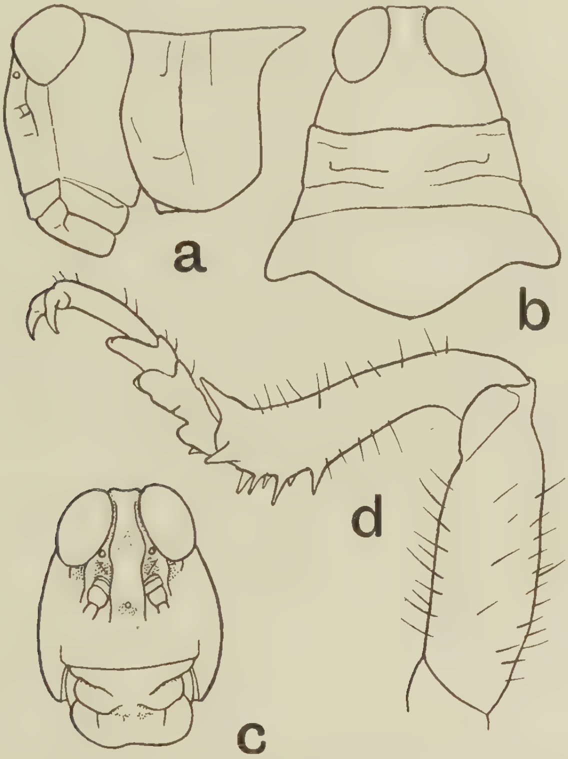

FIG. 13.—*Xenotettix albicans*, sp. n.

A. Head and pronotum from side. B. Head and pronotum from above. C. Head from front. D. Front leg.

Total length	19·0 mm.
Pronotum	3·5 mm.
Elytra	15·0 mm.
Posterior femora	11·0 mm.

Described from 1 ♀ (type); S.W. AFRICA, 8.–30.xi.1929 (*R. E. Turner*).

Eremotettix capensis, sp. n. (Fig. 14, A–C.)

Antennae sub-moniliform, feebly dorso-ventrally compressed for their entire length; sub-equal in length to pronotum. Eyes sub-spherical, prominent; distance between the eyes slightly less than greatest fastigial width. Fastigium of vertex from above narrowly rounded apically, with a median apical incisure; margins thickened and sinuate; surface depressed and tuberculate. Frontal ridge in profile strongly rounded and projecting between antennae; almost straight but irregularly thickened below ocellus; from the front narrow, margins thickened, arcuate at ocellus, thence diverging feebly for about a third of the distance between ocellus and clypeus and then strongly divergent to clypeus; sulcate and feebly tuberculate throughout. Lateral facial carinae arcuate, irregularly thickened, not reaching clypeal suture. Surface of entire insect except abdomen tuberculate. Pronotum from above rhomboidal, laterally constricted in prozona, with the lateral and posterior margins of disc strongly tuberculate, and irregularly thickened; disc tridentate behind, strongly depressed in prozona and apical and basal areas of metazona; with an irregular raised area on median carina at base of prozona; anterior margin obtuse angulate, emarginate and tuberculate; in profile median carina irregularly sinuate. Posterior femora with the upper carina irregularly dentate tuberculate; external face very strongly and irregularly tuberculate. Cerci slender, laterally compressed, narrowly rounded and curving inwards apically. Supra-anal plate too distorted to allow of description. Elytra slightly exceeding the apex of posterior femora, coriaceous and somewhat densely reticulate.

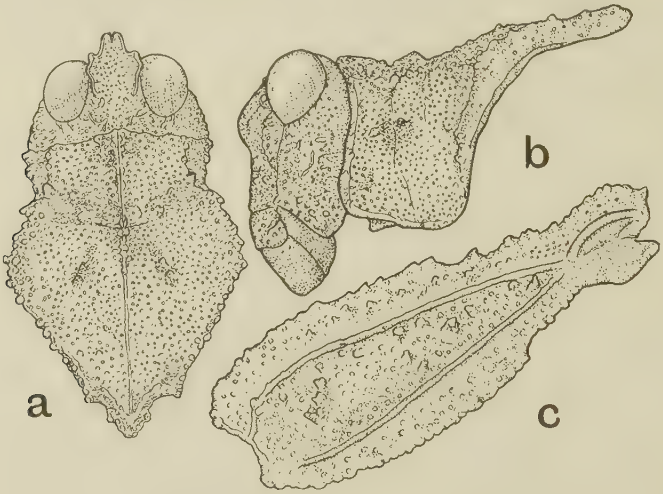

FIG. 14.—*Eremotettix capensis*, sp. n.
A. Head and pronotum from above. B. Head and pronotum from side. C. Posterior femur.

General coloration brown, with black, dark brown and whitish tubercles. Internal face of posterior femora black except near knee, where pinkish; lower internal face pink; internal genicular lobes with a reddish suffusion. Posterior tibiae with a bluish-black suffusion in the basal and external apical area, and the remainder except extreme base suffused with red; spines pinkish tipped with dark brown. Posterior tarsi pale ochreous suffused with pink on upper surface. Pronotum with a diagonal suffused spot on anterior area of metazona, and a transverse blackish suffusion between pro- and metazona. Abdomen pale brownish or greyish-ochreous with some brownish suffusion dorsally. Elytra greyish with reddish-brown venation and some black spots in basal half. Wings faintly blue with the basal sub-costal and apical areas infumate.

Total length	20·5 mm.
Pronotum	7·0 mm.
Elytra	16·0 mm.
Posterior femora	11·0 mm.

Described from 1 ♂ (type); Middleburg, CAPE PROVINCE, Nov. 1916.

Crypsiceracris, gen. nov.

Robust. Apterous. Antennae very short, not exceeding the vertex; 10-segmented; apical segment feebly clubbed; fitting into vertical grooves when in repose; base of antennae separated from the base of the eyes by about the length of an eye. Head large, smooth. Eyes relatively small, sub-prominent, somewhat flattened above. Frontal ridge in profile almost straight; feebly depressed at median ocellus; from the front parallel, sulcate to a point level with the lower margin of the eyes, then smooth and widely divergent to antennae, thence obsolete. Fastigium of vertex from above truncate and concave apically; apical margin sinuate, surface medially depressed. Pronotum considerably broader posteriorly than anteriorly, smooth with scattered tubercles and with no trace of median or lateral carinae; posterior area of metazona thickened with margin irregularly tuberculate; lateral lobes strongly impressed, with the posterior half of lower margin somewhat thickened, recurved and strongly tuberculate. Sternum as in *Crypsicerus*. Abdomen without a tympanum. Posterior femora strongly dilated with the upper carina irregularly dentate and the lower carina irregularly thickened; ridges on external face irregularly thickened and reticulate. Posterior tibiae robust with an apical spine on apical margin, with 5 spines on outer, and 7 spines, including an apical spine, on inner margin; spines on inner margin shorter than spines on outer margin. Base of tibiae with an incision. Spurs sub-equal in length.

Crypsiceracris glabra, sp. n. (Fig. 15, A–D.)

Antennae feebly dorso-ventrally compressed, about as long as the greatest width between the eyes. Head higher than broad. Anterior margin of pronotal disc concave; transverse sulcus interrupted mid-dorsally. Metanotum and dorsum of 1st and 2nd abdominal segments with low tubercles near posterior margin. Supra-anal plate ovate dorso-ventrally compressed in apical half. Cerci very short, thick, triangular.

Antennae, head, anterior and median legs and posterior femora whitish. Eyes brownish-ochreous. Antennal grooves violaceous. Vertex with two blackish spots and orange suffusion at base. Nota and greater part of abdomen dorsally brownish-ochreous; remainder of abdomen dorsally whitish. Sternites and abdomen ventrally pale brownish-ochreous. Genicular arches on posterior femora dark violaceous. Posterior tibiae whitish with a reddish suffusion basally and apically and a broad violaceous stripe on outer surface; spines whitish, faintly suffused with reddish and tipped with brown. Apical spurs tipped with brown.

Total length	36·0 mm.
Pronotum	8·0 mm.
Posterior femora	14·0 mm.
Greatest width of pronotum	15·0 mm.

Described from 1 ♀ (type); Rotkop, 22 m. E. of Lüderitz, S.W. Africa, Dec. 1929 (*R. E. Turner*).

The unusual modification of the front of the head found in the genera *Crypsicerus* and *Lathicerus*—*i.e.* the presence of vertical grooves into which the antennae are placed when in repose—is also present in this genus, which is therefore placed in the same group.

The type of *Crypsicerus cubicus*, Sauss. (kindly loaned to the British Museum by the Director of the South African Museum), and a specimen of *Lathicerus cimex*, Sauss., have been examined by me, and since neither of these striking species has been figured hitherto, figures are now given (Fig. 16, A, B).

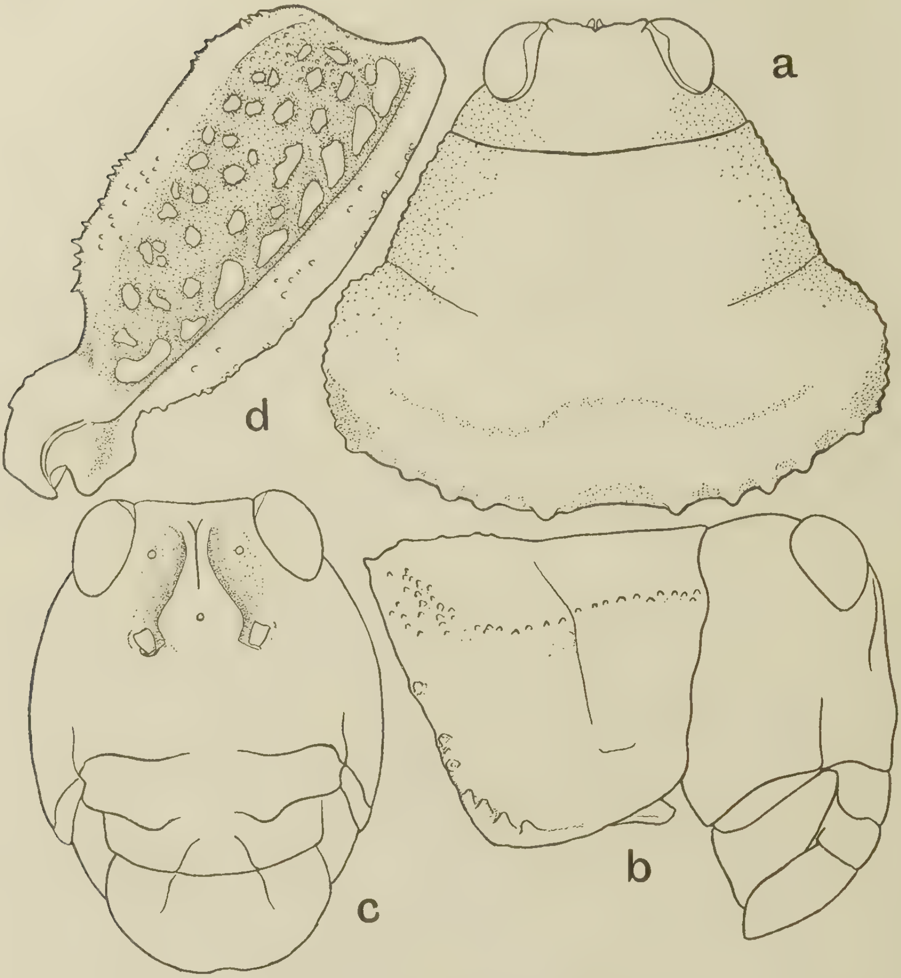

Fig. 15.—*Crypsiceracris glabra*, gen. et sp. n.
A. Head and pronotum from above. B. Head and pronotum from side. C. Head from front. D. Posterior femur.

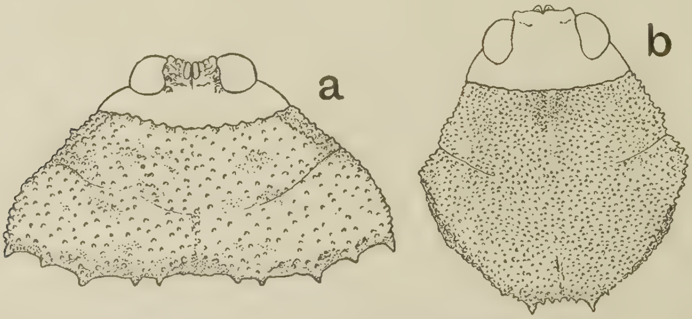

Fig. 16.—A. *Lathicerus cimex*, Sauss. Head and pronotum from above. B. *Crypsicerus cubicus*, Sauss. Head and pronotum from above.

In order to facilitate the separation of the genera, the following key is offered.

1 (2) Posterior tibiae without an inner apical spine. Pronotum rhomboidal, not much wider than long, produced behind. Sternum normal. *Crypsicerus.*

2 (1) Posterior tibiae without an inner apical spine. Pronotum strongly transverse, not produced behind.

3 (4) Pronotal disc flat, more than twice as wide as long; hind margin practically straight. Head and pronotum densely tuberculate. Median area of mesosternum very short, the interspace coming nearly to the anterior margin of the mesosternum . . . . . *Lathicerus.*

4 (3) Pronotal disc feebly convex, less than twice as wide as long, rounded behind. Head and pronotum smooth. Sternum normal. *Crypsiceracris.*

Sub-Fam. Pamphaginae.

Thrincotropis capensis, sp. n. (Fig. 17, A and B.)

Antennae with all segments except three at apex tricarinate; two sub-apical segments feebly flattened on upper surface. Fastigium of vertex rounded apically with a feeble median incisure; lateral margins produced backwards forming a bilobate carina which curves forwards basally to the eye; median carina on vertex almost smooth. Base of disc of prozona of pronotum with a strong tuberculate process rounded apically. Abdomen with mid-dorsal carina reaching to posterior margin on segment 1, and almost to posterior margin, and becoming less distinct, on segments 2–7; apex of projections on mid-dorsal carina rounded. Pronotum and abdomen with irregular longitudinal carinae. Carinae on posterior femora dentate, tuberculate. Elytra rudimentary, squamiform. Prosternal tubercle irregularly thickened with a shallow longitudinal sulcus on apex and two low tubercles on each side of sulcus at base.

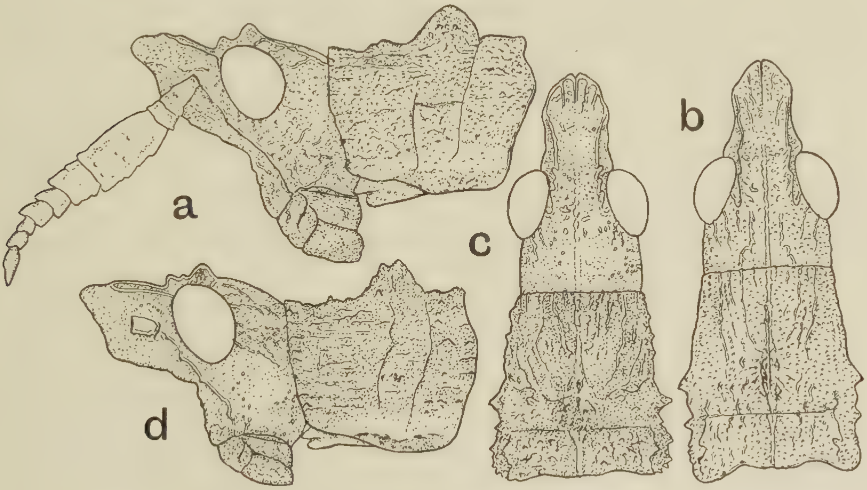

Fig. 17.—*Thrincotropis capensis,* sp. n. A. Head and pronotum from side. B. Head and pronotum from above.—*Thrincotropis trilobata,* sp. n. C. Head and pronotum from above. D. Head and pronotum from side.

General coloration brown, with whitish and black tubercles. Lateral lobes with a light brown fascia near lower margin. Posterior tibiae suffused with crimson on upper surface. Antennae with black suffusion.

Total length	28·5 mm.
Pronotum	4·5 mm.
Elytra	2·0 mm.
Posterior femora	10·5 mm.

Described from 1 ♀; Matjesfontein, CAPE PROVINCE, 6–15.x.1928 (*R. E. Turner*).

Thrincotropis trilobata, sp. n. (Fig. 17, C and D.)

Apex of fastigium rounded with a deep median incisure; lateral margins obtuse angulate and sinuate, and produced backwards forming a trilobate carina which recurves basally towards the eye; surface of fastigium deeply impressed medially; anterior half with subparallel rows of contiguous tubercles; median carina distinct and somewhat irregularly thickened; vertex and genae strongly tuberculate with single and contiguous tubercles; lateral facial carinae sinuate and tuberculate. Eyes prominent and regularly ovate. Frontal ridge sub-rectangulate. Pronotum strongly rugose and tuberculate; base of disc of prozona with a strong tuberculate process bilobate apically; lateral lobes irregularly impressed and tuberculate. Elytra squamiform, reaching just beyond posterior margin of mesonotum. Carina on posterior femora strongly tuberculate and serrate; lower margin of genicular lobes irregularly thickened. Abdomen with longitudinal sulci and carinae and with a sub-median mid-dorsal rounded projection on segments 1–7. Prosternal tubercle irregularly thickened, tuberculate, feebly laterally compressed and deeply transversely depressed near anterior margin.

Antennae missing. General coloration dark brown with whitish tubercles on head and femora, and black tubercles on head, nota, abdomen and posterior femora, and black suffusion sub-dorsally and laterally on abdomen. Nota with irregular black suffusion. Posterior tarsi suffused with crimson on upper surface. Lateral lobes with light brown fascia near lower margin.

Total length	30·5 mm.
Pronotum	4·0 mm.
Elytra	1·0 mm.
Posterior femora	9·5 mm.

Described from 1 ♀; Matjesfontein, CAPE PROVINCE, 6–15.x.1928 (*R. E. Turner*).

KEY TO *THRINCOTROPIS* SPP.

1 (4) Tubercle on the metazona of pronotum rounded in profile. Carina at the base of the fastigium bilobate in profile.

2 (3) Apex of fastigium of vertex acute with a median incisure; posterior margin of pronotal disc emarginate . . . . *caffra.*

3 (2) Apex of fastigium narrowly rounded with a feeble median incisure; posterior margin of pronotal disc feebly concave and irregularly thickened . . . . *capensis.*

4 (1) Tubercle on metazona of pronotal disc bilobate in profile. Carina at base of fastigium trilobate in profile; apex of fastigium narrowly rounded with a strong median incisure; posterior margin of pronotal disc sinuate . . . . *trilobata.*

Sub-Fam. PYRGOMORPHINAE.

Cawendia vittata, sp. n. (Fig. 18, A and B.)

Antennae moniliform, punctate and feebly compressed dorso-ventrally in basal third. Eyes sub-pyriform. Surface of head rugose and with irregular tubercles below and behind the eyes. Frontal ridge in profile feebly concave; from the front, margins sub-parallel to median ocellus, thence feebly divergent and sinuate to clypeus; lateral facial carinae almost straight. Fastigium of vertex broadly conical, with the lateral margins feebly thickened. Vertex with a moderately distinct but irregular median carina. Anterior margin of pronotal disc feebly concave; posterior margin strongly concave; margins of lateral lobes sinuate; inferior margin thickened; surface of pronotum strongly rugose with irregular tubercles along inferior margin of lateral lobes; surface of pleura and dorsum of segments 1–3 of abdomen rugose. Supra-anal plate conical, smooth apical margin of sub-genital plate feebly concave with a median projection. Cerci simple, conical. Margins of ovipositor valves irregularly serrate basally. Posterior femora reaching beyond apex of abdomen.

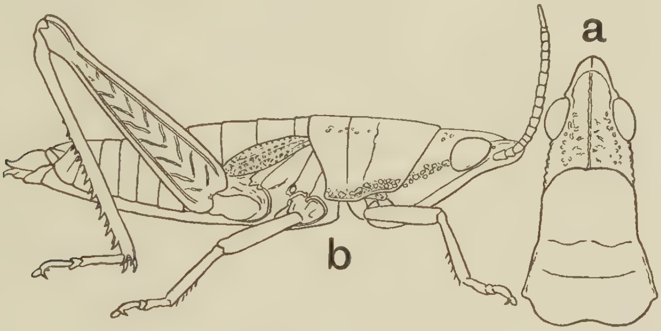

FIG. 18.—*Cawendia vittata,* sp. n.
A. Head and pronotum from above. B. Whole insect from side.

Elytra narrow, strongly coriaceous, reaching just beyond apical margin of 1st abdominal segment. Wings about half the length of elytra.

General coloration greenish-ochreous. Basal segments 1 and 2 of antennae green, remainder black with reddish suffusion in basal third. Eyes light brown with dark brown stripes and suffusion. Lateral margins of fastigium of vertex red; genae with a row of pale ochreous tubercles from the base of the eye to the inferior anterior angle of lateral lobes of pronotum; vertex with some scattered pale ochreous tubercles behind the eyes. Pronotum with a narrow reddish stripe along the median carina connecting with a stripe of same colour along the mid-dorsum of abdomen to the 8th segment; abdomen with a faint black spot laterally on segments 1–6, and a pale ochreous stripe above the spots. Elytra pale green.

Total length	23·0 mm.
Pronotum	5·0 mm.
Elytra	4·5 mm.
Posterior femora	11·0 mm.

Described from 1 ♀ (type), Reitspruit, Marico, TRANSVAAL; and 1 ♀, Zeerust, Marico, TRANSVAAL (*J. C. Faure*).

Sub-Fam. CATANTOPINAE.

Rhamphacrida coerulescens, sp. n. (Fig. 19, A and B.)

Prosternal tubercle strongly laterally compressed with the anterior margin rounded and the posterior margin straight. Surface of face and vertex rugose; genae smooth with some punctures.

Antennae reddish-brown. Eyes light brown. Face blackish-brown; vertex greyish-brown; sides of head with a moderately broad brownish-ochreous stripe extending from the antennae along the lower margin of the eye and of the genae; genae with whitish suffusion. Pronotum dark brown with a broad brownish-ochreous stripe along lower margin of lateral lobes. Pleura dark brown with a broad horizontal brownish-ochreous stripe above coxal cavity on mesopleura to coxae of posterior legs. Anterior and median legs brown; posterior femora with the upper faces slightly suffused with red, the internal face violaceous with some white spots, and the lower internal face greyish; a pre-genicular spot present on internal face. Posterior tibiae light brown with a black suffusion basally and apically; spines broadly tipped with black. Wings hyaline, very faintly greenish-blue basally.

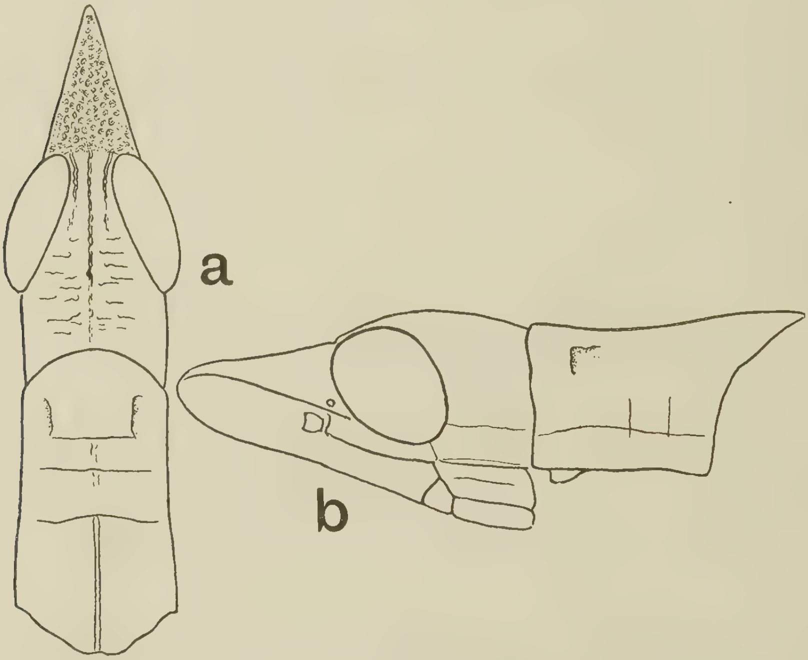

FIG. 19.—*Rhamphacrida coerulescens,* sp. n.
A. Head and pronotum from above. B. Head and pronotum from side.

Total length	45·0 mm. (approx., apex of sub-genital plate broken).
Pronotum	5·5 mm.
Elytra	26·5 mm.
Posterior femora	14·0 mm.

Described from 1 ♂ (type); Gomma, ABYSSINIA, 22.iii.1904 (*C. Singer*).

Closely resembles *R. kraussi*, Karsch. The only differences I was able to discover by comparing this individual with specimens from N. Nigeria, Cameroons, and Tanganyika Territory are the following. In this species the fastigium of the vertex is more narrowly rounded, and in profile that part of the vertex between the eyes is flattened.

Ischnacrida pretoriae, sp. n. (Fig. 20, A–D.)

Antennae moniliform and moderately compressed dorso-ventrally. Fastigium of vertex produced, triangular, apex narrowly rounded; shallowly sulcate; vertex with a distinct median longitudinal carina. Frontal ridge in profile almost straight; from the front, margins strongly divergent from a point above the antennae to clypeus; surface of face and fastigium of vertex rugose, remainder of head smooth. Prosternal spine strongly compressed laterally, inclined backwards. Supra-anal plate ♂ triangular, narrowly rounded apically, laterally depressed and with a strong median longitudinal sulcus broader at the base than at apex; sub-genital plate ♂ produced, narrowly rounded apically, strongly laterally compressed; supra-anal plate ♀ triangular, rounded apically, laterally compressed and with a median longitudinal sulcus; sub-genital plate ♀ with the apical margin trilobate. Elytra reaching just beyond apical margin of 6th abdominal segment in ♂, and 4th segment in ♀.

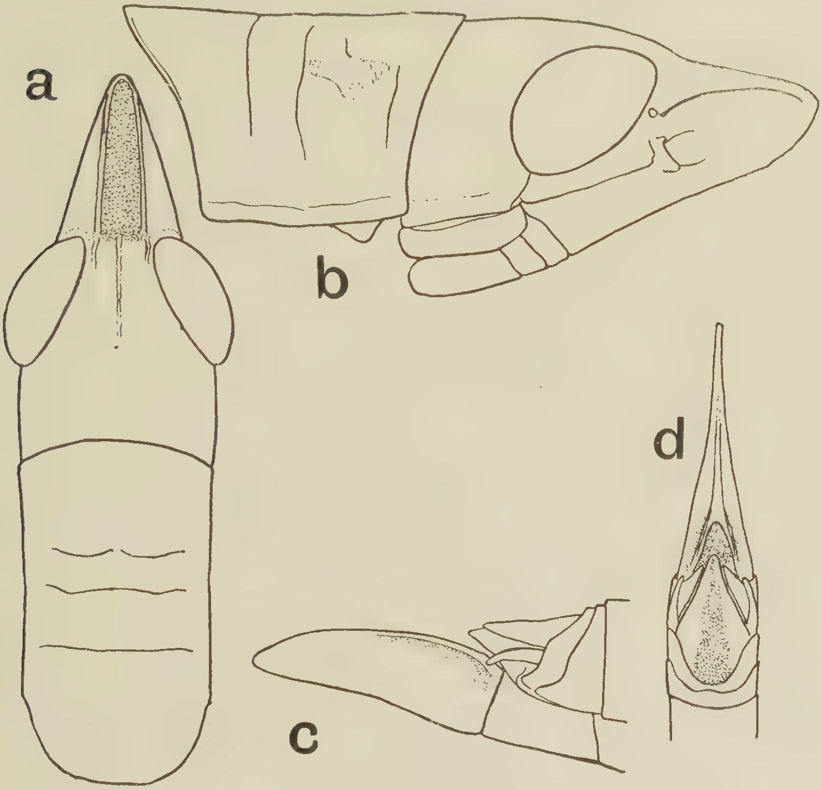

Fig. 20.—*Ischnacrida pretoriae*, sp. n
A. Head and pronotum from above. B. Head and pronotum from side. C. Sub-genital plate ♂ from side. D. Apex of abdomen ♂ from above.

Antennae pale purplish-brown. Eyes light brown. Face dark brown; genae greyish-brown with irregular horizontal dark brown stripes and with the lower margin pale ochreous. Fastigium of vertex dark brown with two parallel, narrow, ochreous stripes from apex to base of head, becoming broader behind the eyes; space between the ochreous stripes dark brown. Pronotal disc ochreous with a median, longitudinal, moderately broad brown stripe. Lateral lobes brown with the lower area ochreous becoming whitish-ochreous on lower margin. Pleura dark brown with a horizontal ochreous stripe above the coxal cavity on mesopleura; mesosternal episternum with a trace of an ochreous stripe. Abdomen castaneous; subgenital plate of ♂ reddish-brown. Legs brown; posterior femora with the lower half pale ochreous and with a blackish serrate stripe on internal face.

Elytra with reddish and pale ochreous venation basally. Wings hyaline and faintly pink basally.

	♂	♀
Total length	41·0 mm.	56·0 mm.
Pronotum	6·0 mm.	9·0 mm.
Elytra	22·0 mm.	24·0 mm.
Posterior femora	14·0 mm.	19·0 mm.

Described from 1 ♂ (type) and 1 ♀; Pretoria, TRANSVAAL, 11.ii.1926.

Ischnacrida carinata, sp. n. (Fig. 21, A–C.)

Fastigium of the vertex conical with the apex rounded, and with a spatulate depression. Frontal ridge in profile straight; from the front, margins raised, divergent from above ocellus to clypeus; surface rugose. Median carina on vertex distinct, becoming obsolescent towards base of head.

Prosternal spine strongly laterally compressed, with the apex rounded and feebly transversely impressed; anterior margin with a feeble longitudinal sulcus.

Supra-anal plate narrowly triangular, acute with three deep longitudinal sulci converging towards apex; subgenital plate produced (apex broken in specimen under examination). Cerci simple, curving inwards. Elytra reaching almost to apical margin of 8th abdominal segment, and just beyond apex of posterior femora.

Antennae reddish-brown. Eyes light brown. Head brownish-olivaceous, with dark brown stripes from the apex of the vertex to the base of head and on genae; lower area of genae pale ochreous. Pronotum horizontally and irregularly striped with dark brown, brownish-ochreous and olivaceous; lower margin of lateral lobes pale ochreous. Pleura olivaceous with an ochreous stripe above coxal cavity on mesopleura to the anterior margin of coxal cavity on metapleura. Abdomen brownish. Legs brownish. Internal face of posterior femora with a black stripe along lower carina, and with oblique ridges black; lower external face ochreous. Wings hyaline.

Total length (approx.)	36·0 mm.
Pronotum	6·0 mm.
Elytra	20·0 mm.
Posterior femora	15·0 mm.

Described from 1 ♂ (type); Eshowe, ZULULAND, July 1926 (*R. E. Turner*).

Lentula tuberculata, sp. n. (Fig. 22, A–C.)

Antennae moniliform, finely setose, reaching beyond the base of hind femora. Eyes sub-reniform. Surface of head rugose, less so on base of vertex. Frontal ridge in profile almost straight; from the front, margins converging to median ocellus, thence divergent to clypeus; surface of ridge feebly sulcate and rugose. Fastigium of vertex strongly

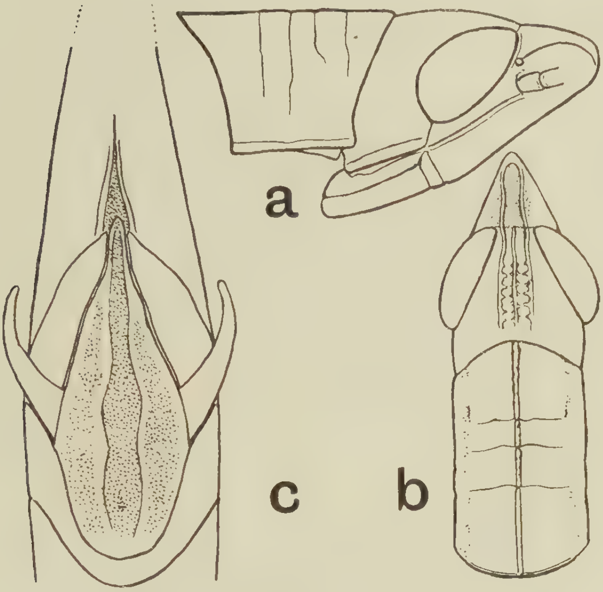

FIG. 21.—*Ischnacrida carinata*, sp. n.
A. Head and pronotum from side. B. Head and pronotum from above. C. Apex of abdomen ♂ from above.

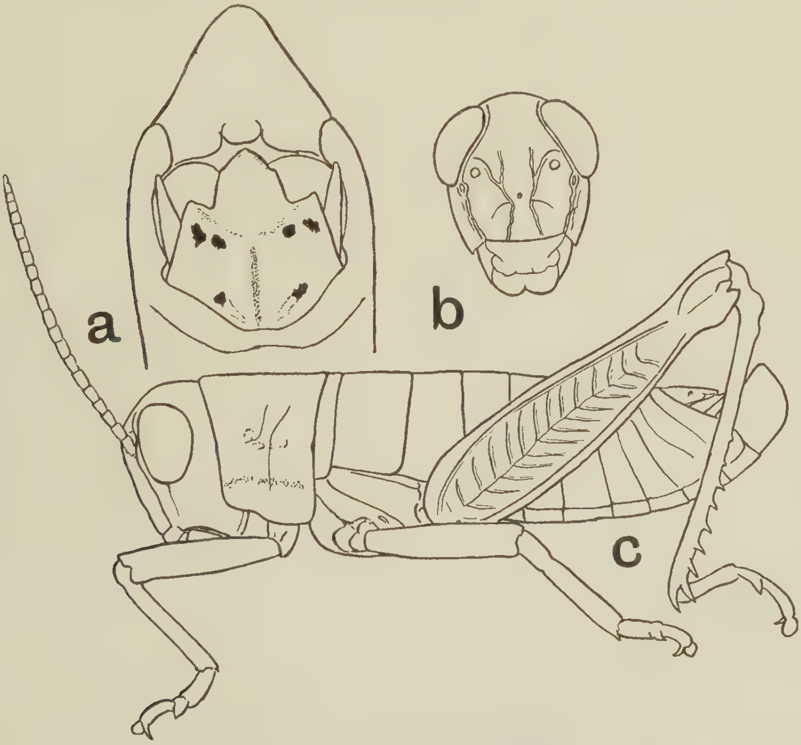

FIG. 22.—*Lentula tuberculata*, sp. n.
A. Apex of abdomen ♂ from above. B. Head from front. C. Whole insect from side.

declivent, forming a very broadly rounded angle with frontal ridge. Distance between eyes equal to greatest width of frontal ridge. Surface of pronotum rugose punctate, anterior and posterior margins of disc broadly rounded; anterior and posterior margins of lateral lobes straight; inferior margin sinuate; pronotum regularly sellate. Supra-anal plate ♂ tricuspidate, with a short median longitudinal sulcus basally, a low tubercle on each side of sulcus and two low tubercles near the lateral projection; sub-genital plate ♂ truncate and laterally compressed apically. Supra-anal plate ♀ conical with a feeble median longitudinal sulcus basally and a sub-median transverse sulcus; sub-genital plate ♀ quadrate with the apical margin rounded and with a strong median projection. Margins of ovipositor valves smooth. Apices of posterior femora not reaching apex of abdomen. Apterous. Cerci ♂ and ♀ simple. Head and body with scattered setae; ventral surface of abdomen, anterior and median legs and posterior tibiae and tarsi abundantly setose.

Antennae and eyes dark brown. Head and body olivaceous. Legs greenish-ochreous. Supra-anal plate of ♂ with black tubercles.

	♂	♀
Total length	12·5 mm.	20·0 mm.
Pronotum	2·5 mm.	4·0 mm.
Posterior femora	8·0 mm.	9·5 mm.

Type ♂. Described from 3 ♂♂ and 1 ♀; Pretoria, TRANSVAAL, 6.iii.1923.

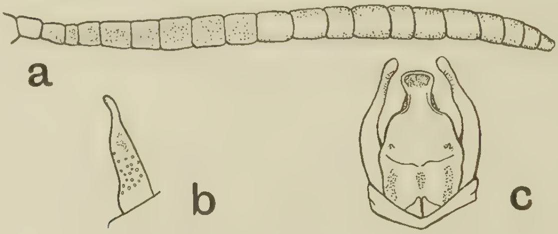

FIG. 23.—*Eucoptacra turneri*, sp. n.
A. Antenna. B. Cercus, ♂. C. Apex of abdomen ♂ from above.

Eucoptacra turneri, sp. n. (Fig. 23, A–C.)

Antennae slightly shorter than head and pronotum together. Distance between eyes sub-equal to greatest fastigial width. Fastigium and vertex strongly irregularly punctured. Frontal ridge in profile almost straight; from the front, margins converging from above antennae to clypeus; surface strongly punctate and feebly convex. Face and genae strongly rugose punctate; lateral facial carinae irregularly sinuate. Pronotum feebly laterally compressed in prozona; median carina low but acute; posterior margin of disc, lower and posterior margins of lateral lobes thickened. Prosternal spine transverse, narrowly rounded apically. Upper external face of posterior femora feebly tuberculate; lower external face strongly punctate along outer margin. Supra-anal plate ♂ ovate, strongly laterally compressed near apex with a low tubercle on each side of base of apical half and with three longitudinal depressions in basal half; sub-genital plate ♂ conical, feebly compressed near apex. Supra-anal plate ♀ triangular, rounded apically, and strongly compressed laterally (more so in apical half) and with an ovate depression in basal half; sub-genital plate ♀ quadrate, with the apical margin produced medially. Cerci reaching beyond apex of abdomen, strongly compressed laterally, slender and curving downwards and inwards in apical half. Upper carina of posterior femora widely serrate; oblique ridges on outer face punctate. Elytra with the costal lobe moderately well developed.

Brownish-ochreous. Antennae reddish-brown with some black diffusion apically. Vertex suffused with black; face, genae and pronotum with some black maculation. Pleura with a blackish suffusion at base of mesosternal epimeron and metasternal episternum. Anterior and median legs with black maculation; posterior femora with black maculation on carinae and oblique ridges, black suffusion on upper surface near knee, the lower external face black and the internal face strongly suffused with orange; posterior tibiae reddish, suffused with black and brown basally; spines pale reddish tipped with black; posterior tarsi reddish basally, brown apically. Elytra with some faint brownish maculation apically. Wings pale amber.

	♂	♀
Total length	12·5 mm.	15·0 mm.
Pronotum	3·0 mm.	4·9 mm.
Elytra	11·0 mm.	13·0 mm.
Posterior femora	8·0 mm.	10·0 mm.

Described from 5 ♂♂ and 3 ♀♀; Port St. John, Pondoland, S. AFRICA, May 1924 (*R. E. Turner*). Type ♂.

Bocagella bolivari, sp. n. (Fig. 24, A–D.)

♂. Antennae sub-equal to pronotum. Margins of frontal ridge thickened; from the front, arcuate from above antennae to below median ocellus, thence parallel and sinuate to clypeus; in profile almost straight; surface deeply punctate throughout. Fastigium of vertex from above strongly sloping, forming hardly any angle with frontal ridge in profile; surface deeply impressed and punctate; lateral margins strongly raised acute angulate and meeting a strong median carina on vertex. Lateral facial carinae irregularly sinuate; genae deeply and irregularly impressed. Pronotum regularly arcuate in profile with the posterior angle recurved and thickened; upper area of lateral lobes moderately deeply irregularly impressed. Prosternal spine sub-cylindrical with the apex rounded. Supra-anal plate, pyriform with the apex narrowly rounded, the sides feebly thickened near apex and feebly sinuate in remainder; surface feebly concave with two short tubercles in apical half; sub-genital plate conical with the apex rounded. Cerci triangular, curving inwards in apical half. Elytra obliquely truncate apically with the apical angle rounded, and costal lobe moderately well developed. Wings with the apical angle acute and the immediate angle rounded.

Dark fulvous. Head with some black spots behind the eyes. Pronotum with an oblique black fascia on lateral lobes in prozona and a black suffused area on median carina and on mesozona of disc. Posterior femora with the internal face brownish-ochreous, three transverse black fasciae on internal and external upper faces and lower external face. The basal and apical fasciae are somewhat indistinct and the apical fascia is continued on to the inner face. Posterior tibiae light brown suffused with black, particularly on internal face. Elytra hyaline with reddish-brown venation and some infumation on each side of cross-veins apically. Wings yellow, infumate in apical half and with a strong infumate area at apical angle which extends to base of wing.

The ♀ differs from the ♂ principally in the colour of the wings which are not so yellow and are less infumate apically, and in the absence of black markings on head and pronotum. The transverse fasciae on posterior femora are less distinct.

	♂	♀
Total length	15·0 mm.	18·0 mm.
Pronotum	7·0 mm.	8·0 mm.
Elytra	15·0 mm.	17·0 mm.
Posterior femora	11·0 mm.	12·5 mm.

Type ♂. Described from 3 ♂♂ and 8 ♀♀; Tukuyu, TANGANYIKA TERRITORY, 1924 (*N. C. E. Miller*). This species was recorded by me as *Bocagella lanuginosa*, Bol. (1925, Ann. Mag. Nat. Hist., (9) **15**: 629.)

This species differs from *Bocagella lanuginosa*, Bol., in its smaller size (the elytra and posterior femora are longer, however), the colour of the wings and posterior tibiae.

The species is named after Dr. Ignacio Bolivar, the author of the genus.

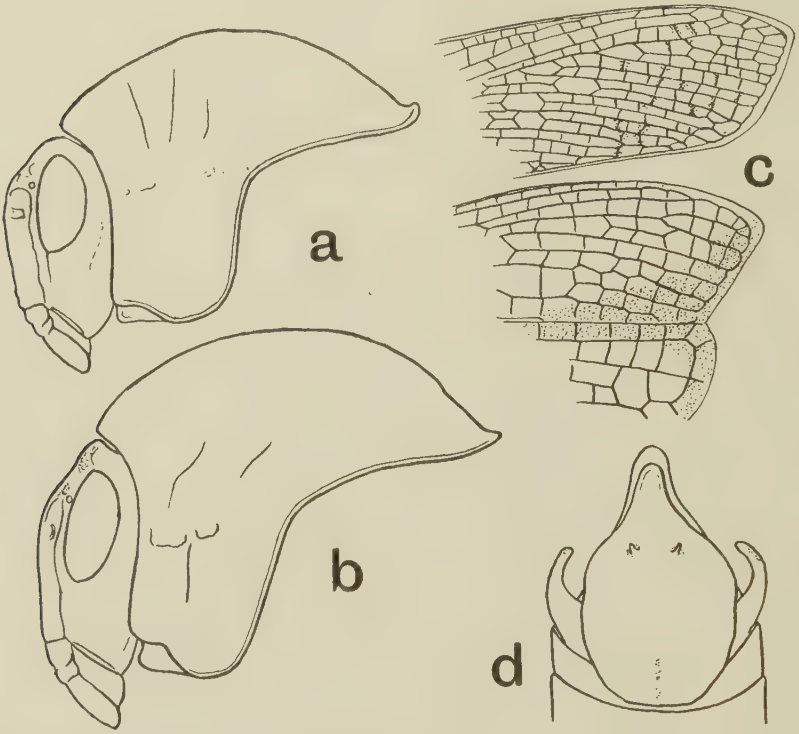

FIG. 24.—*Bocagella bolivari*, sp. n.
A. Head and pronotum from side, ♂. B. Head and pronotum from side, ♀. C. Apex of elytron and wing. D. Apex of abdomen ♂ from above.

Bocagella acutipennis, sp. n. (Fig. 25, A and B.)

Antennae filiform, feebly dorso-ventrally compressed in basal fourth. Frontal ridge in profile almost straight; from the front, margins thickened, arcuate from above antennae to median ocellus, then sinuate for about half the distance between ocellus and clypeus, then straight and parallel to clypeus; surface deeply sulcate, rugose and with a deeper longitudinal depression between antennae. Fastigium of vertex strongly sloping forming hardly any angle with frontal ridge, with the lateral margins strongly raised, acutely angulate and meeting a strong median carina on vertex; surface concave. Lateral facial carinae irregularly sinuate; genae with three irregular diagonal sulci. Median carina of pronotum irregularly sinuate in basal half of metazona, and with the base irregularly thickened and recurved; posterior margin thickened at juncture with median carina; lateral lobes with low tubercles. Prosternal spine cylindrical with the apex rounded; compressed anteriorly posteriorly and laterally at base. Supra-anal plate rhomboidal, laterally compressed, with a median longitudinal sulcus basally and a median transverse sulcus; sub-genital plate quadrate; apical margin with a strong median mucronate projection. Elytra obliquely truncate apically with the apical angle acute. Wings with the apex acutely angulate and the apical margin feebly concave.

Pale fulvous. Frontal ridge, median carina of pronotum brownish. Lateral lobes with some blackish tubercles. Abdomen pale brownish-ochreous. Posterior femora with some of the serrations and spots on carinae black, a trace of blackish transverse bands on external faces and with two black bands on internal face and a black spot on internal genicular lobe. Posterior tibiae pale greyish-brown with black suffusion on inner face, particularly in apical half; spines tipped with brown. Elytra hyaline with pale fulvous and reddish venation in basal area, greyish-brown venation and some pale infumate spots in apical area. Wings hyaline with a narrow dark infumate area apically.

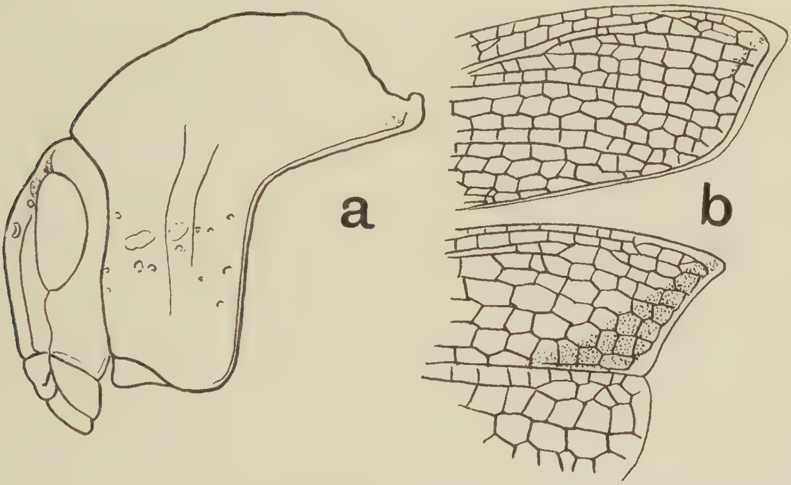

Fig. 25.—*Bocagella acutipennis*, sp. n.
A. Head and pronotum from side. B. Apex of elytron and wing.

Total length	21·0 mm.
Pronotum	7·0 mm.
Elytra	18·0 mm.
Posterior femora	11·0 mm.

Described from 1 ♀; Mama Dist., Akwanga Div. N.P., Nigeria, ii.1928 (*Dr. Ll. Lloyd*).

Differs from *Bocagella lanuginosa*, Bol. (I. Bolivar, Ortopteros de Africa del Museo de Lisboa, 1889, J. Sci. Math. Phys. Nat. Lisboa, **1**: 161–2), in its larger size, the shape of the pronotum, which is more rounded and with the base of the median carina strong recurved, and also in the colour of the wings, posterior femora and tibiae.

This species also differs from *Bocagella bolivari* described in the present paper in the shape of the elytra, wings and pronotum.

ENTOMOLOGICAL EXPEDITION TO ABYSSINIA, 1926–7. HYMENOPTERA, I: APOIDEA (EXCLUSIVE OF *ANDRENA* AND *HALICTUS*)

By J. D. Alfken (Bremen).
Translated and annotated by Hugh Scott.

[Read December 2nd, 1931.]

The main purpose of this paper is to give an account of the bees collected by Dr. Hugh Scott and Mr. J. Omer-Cooper in the highlands of Central Abyssinia in 1926 and 1927, excepting the genera *Halictus*, *Andrena* and *Eupetersia*, which are being dealt with by Herr Blüthgen, whose report will appear later. It has, however, been found convenient to include some previously unnamed material in the British Museum, viz. specimens collected by the Hungarian naturalist, the late O. Kovacs, in 1914, by Mr. (now Col.) R. J. Stordy in 1911,* and by Mr. P. C. Zaphiro (now Oriental Secretary to the British Legation at Addis Ababa) at an earlier date.

Hymenoptera were not the principal object of Scott's and Omer-Cooper's expedition, and the specimens here dealt with represent part of the results of general insect-collecting. Certain species of *Nomia*, *Tetralonia* and *Megachile* are left out of the report and must remain unidentified at present, owing to the inadequacy of the material and the defective or chaotic state of knowledge of the African representatives of these genera.

The species collected in the Abyssinian highlands are mostly widely spread in tropical Africa—more particularly East Africa—and sometimes South Africa as well. Out of 20 species enumerated only 4 are unknown outside Abyssinia. One of these, *Xylocopa bicarinata*, sp. n., is closely allied to an East African species. Another, *Xylocopa schoana*, End., superficially resembles the form widely distributed in Africa known as *X. caffra*, L., but possesses clear differentiating characters, among them the absence of the mite-pouch, in the ♀ sex.

Two species (*Colletes rufitarsis* and *Heriades argentatus*) occur also in Kilimanjaro. The only stingless bee (*Melipona*) collected is a species originally described from Mount Elgon; three forms of it are defined below, two of them occurring together in Abyssinia at 8000–9000 ft., while the third is recorded from Ruwenzori.

In contrast to the purely Ethiopian tone of the bees from the highlands, the only species taken close to the coast in French Somaliland (*Nomia latipes*) is South Palaearctic in its range.

Many species have been described or recorded from Abyssinia, notably in a work by Friese, 1915, "Zur Bienenfauna von Abessinien," Deuts. ent. Z., **1915**: 265–298, largely based on material collected by Mr. Gunnar Kristensen at and near Harar.† In the present paper this work is referred to shortly as "Friese 1915." References to the same author's "Die Bienen Afrikas," which appeared in 1909, in L. Schultze, Zool. Ergebn. einer Forschungsreise in westlichen und zentralen Südafrika, 2 (being Denkschr. Med.-Nat. Ges. Jena, **14**) are given shortly as "Friese 1909," the page-references being to the pagination of the complete volume, not of the separate work.

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* At that time Chief Veterinary Officer in Kenya Colony, who made a journey northwards through southern Abyssinia to Addis Ababa.

† Several other lots of Hymenoptera obtained by this collector were acquired by Mr. R. E. Turner and presented by him to the British Museum.

Localities. Jem-Jem [Djem-Djem] Forest, the locality most frequently mentioned, is about 45 miles nearly due west of Addis Ababa. Wouramboulchi lies some miles to the west of Jem-Jem. Addis Alam is about 20 miles west of Addis Ababa, on the road to Jem-Jem. The Akaki River is a tributary of the Hawash, close to Addis Ababa, mainly east and south. Doukam is about 20 miles south-east of the capital, being the name of a river and also of the second railway-station from Addis Ababa. Mt. Chillálo refers to the westernmost of the high Arussi mountains, immediately east of Lake Zwai. Mulu, above the Muger valley, is a little over 30 miles from Addis Ababa, west of north.

Attempts to trace "Maraquo," where Kovacs collected many specimens, have been unsuccessful, unless it be the "Maroko Mts.," west or south-west of Lake Shala. There is also some uncertainty about the places visited by Stordy called "Higo Samula," "Gatelo Amaiyu" and "Alaba." The two former are probably east of the south end of Lake Abaya [Margherita], and the third may be a district south of Lake Shala.

The *types* of the new species and all the rest of the material, except some duplicates retained by the author, are in the British Museum.

COLLETES, Latreille.

Two Abyssinian species were described as new to science by Friese in 1915; one of these is represented in the collection under review, as is also an East African species not previously recorded from Abyssinia.

Colletes abessinicus, Friese, 1915, pp. 268, 278.

Loc. ABYSSINIA: Jem-Jem Forest, *ca.* 8000 ft., 23.ix.1926, 1 ♂ (*Omer-Cooper*); the species was described in the ♂ sex only from examples taken at Harar in November (*Kristensen*).

Colletes rufitarsis, Friese, 1908, in Sjöstedt, Zool. Kilimandjaro–Meru Exp., **2**, (8) No. 5: 121; *id.*, 1909, p. 121.

Loc. ABYSSINIA: Jem-Jem Forest, *ca.* 8000 ft., 25 or 26.ix.1926, 1 ♂ (*Scott*). The description was based on examples of both sexes taken on Kilimanjaro, some of them at an altitude of 1900 metres (*ca.* 6200 ft.), and the species has been recorded from elsewhere in Tropical Africa.

NOMIA, Latreille.

A number of species of this genus have been recorded from Abyssinia, especially from Harar (see Friese, 1915, pp. 269, 270). Notes are given below on several species obtained by Scott in 1926–7, but some examples must be left undetermined in the present state of knowledge of this genus. Remarks are added on two species not collected by the expedition of 1926–7, in one case because the species does not appear to have been recorded from Abyssinia before, in the other case to settle a question of synonymy.

Nomia tridentata, F. Smith, var. *orientalis*, Friese, 1908, in Sjöstedt, Zool. Kilimandjaro–Meru Exp., **2**, (8) No. 5: 129–130; *id.*, 1909, p. 165; *id.*, 1915, p. 269.

Loc. ABYSSINIA: edge of Jem-Jem Forest, *ca.* 9000 ft., 4.x.1926, 2 ♀ (*Scott*); also 1 ♂ and 1 ♀, the former without exact data, the latter labelled

Addis Ababa, in Brit. Mus. (*Stordy*); Harar, some ♂♂ taken in November (*Kristensen*, recorded by Friese). The species is widely spread in Africa. The British Museum has a series of ♂♂ referred to the variety *orientalis*, from Northern Nigeria, Uganda, Nyasaland and South Africa.

Nomia anthidioides, Gerstaecker, 1857; Friese, 1909, p. 155.

Loc. ABYSSINIA: Mulu, above the Muger Valley, *ca.* 8000 ft., 27.xii.1926, 2 ♀ (*Scott*). Originally described, from the ♀ only, from Mozambique. The British Museum has specimens from Katanga, N.W. Rhodesia, Nyasaland, Zanzibar and various parts of South Africa.

Nomia bouyssoui, Vachal, 1903, Ann. Soc. ent. Fr., **72**: 394; Friese, 1909, p. 172.

This species was described from specimens from the French Congo. It does not appear to have been recorded from Abyssinia, but 1 ♀ in the British Museum is referred to it: Harar (*Kristensen*).

Nomia candida, F. Smith.

Nomia candida, F. Smith, 1875, *Trans. Ent. Soc. Lond.*, **1875**: 68 (♀).
Nomia braunsiana, Friese, 1908, in Sjöstedt, Zool. Kilimandjaro–Meru Exp., **2**, (8) No. 5: 127; *id.*, 1909, p. 160; *id.*, 1915, p. 269 (♂♀).

A comparison of the type of *N. candida* with examples determined by Friese as *N. braunsiana* leaves no doubt of the identity of the two. Friese wrote that *N. braunsiana* is very close to *N. candida*, but has no yellow band on the hind part of the first abdominal tergite; he evidently misunderstood Smith's description, for Smith himself correctly described *N. candida* as having no yellow band, but only a band of white hairs on either side of the first tergite. Another discrepancy occurs in Friese's remarks on *N. braunsiana* published in 1909 and 1915, for in the former he wrote that the ♀ has wide yellow bands on tergites 2–4, in the latter that it has white bands on tergites 2–5. Actually there is a broad band, varying from yellowish-white to yellow, on each of the tergites 2, 3 and 4; tergite 5 is usually concealed, but in one example at least a pale stripe is visible on this segment.

Loc. ABYSSINIA: recorded from Harar, where both sexes were taken plentifully in November (*Kristensen*); not obtained by Scott or Omer-Cooper. The original locality for *N. candida* was Sierra Leone; that for *N. braunsiana* was Kilimanjaro, and it was also recorded by Friese from West Africa, Rhodesia and South Africa. Specimens in the British Museum from Nyasaland and other parts of eastern Africa are referred to this species.

Nomia latipes, F. Morawitz, 1880.

In my opinion *N. magrettii*, Grib., 1884, is almost certainly identical with *N. latipes*,* but both names may prove to be synonyms of *N. lobata*, Olivier, 1811. Olivier's statement that the hind tibiae (in the ♂) end in two yellow plates may be taken to mean that the one large plate is partly divided and looks as though it were two. It will also have to be determined later whether *N. patellata*, Magr., 1884 (of which *N. albifrons*, Vach., 1897, Miscell. Ent., **5**: 74, is the ♀), is a synonym of this species.

Loc. FRENCH SOMALILAND: 12 ♂, all taken together at Ambouli Oasis, near

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* In the British Museum a ♀ from East Africa named *N. magrettii* by P. Blüthgen is not identical with ♀ examples from Sinai and Biskra (the latter ex coll. E. Saunders) placed under *N. latipes*. The latter have the thorax much less closely and more sparsely punctured and there are other differences. There is no ♂ *N. magrettii* to compare with that sex of *N. latipes*.—H. S.

Jibuti, 29.i.1927 (*Scott*). The original locality was the Caucasus. The British Museum has specimens from Palestine, Sinai and Algeria (Biskra).

XYLOCOPA, Latreille.

Many species have been recorded from Abyssinia, especially by Friese, 1915, pp. 270–272. Five were obtained by the expedition under review, one of which is described below as new.

Xylocopa (s. str.) *tarsata*, F. Smith, 1854; Friese, 1909, p. 221; *id.*, 1915, p. 270.

The single example is small, but otherwise agrees closely with two in the British Museum which have been compared with the type.

Loc. ABYSSINIA: Jem-Jem Forest, *ca.* 8000 ft., between 22 and 26.ix.1926, one ♀ (*Scott*); Friese records it from Harar and Eritrea, also as widely spread in East Africa as far south as Lourenço Marques.

Xylocopa (s. str.) *carinata*, F. Smith, 1874; Friese, 1915, p. 271.

The single example corresponds with the type and other examples in the British Museum.

Loc. ABYSSINIA: Jem-Jem Forest, *ca.* 8000 ft., between 22 and 26.ix.1926, 1 ♀ (*Scott*); Friese records both sexes as taken at Harar in November (*Kristensen*). This variable species is widely distributed in Tropical Africa, both east and west, and extends south into Rhodesia and Natal.

Xylocopa (s. str.) **bicarinata,** sp. n.

♀. Length, 21 mm. Black. Frontal keel short, falling away perpendicularly in front, continued as a feeble elevation on either side to the root of the antenna. Clypeus with a similarly formed short keel in the middle, and closely wrinkled-punctate except at the front margin, which is smooth and impunctate. Antennae with the second segment of the funicle as long as the three following segments together. Vertex and thorax covered with dirty-brown hairs, the mesonotum rather thickly. Knee-cap very long, occupying about $\frac{3}{4}$ of the length of the hind tibia, formed as described by Vachal in *X. subjuncta.* Basal segments of front tarsi with yellow hairs at the base on the outer side, their distal portion with rust-red hairs like those on the other segments. Basal segments of middle tarsi furnished with some yellow hairs on the outer side at the base, those of the hind tarsi with only a trace of yellow hairs in the same region. Wings not very dark, but it is difficult to determine the shade, as the insect had evidently been long on the wing.

Very closely related to *X. subjuncta,* Vachal (1898), and agreeing in many characters with his description of that species (see also 1899, Miscell. Ent., **7**: 95). In my opinion *X. subjuncta* is not identical with *X. fraudulenta,* Grib., as it is regarded by Friese (1909, p. 228).

Loc. ABYSSINIA: between Jem-Jem Forest and Wouramboulchi (about 50 miles west of Addis Ababa), 8000–9000 ft., 8–11.x.1926, 1 ♀ (*Omer-Cooper*).

[*Translator's Note.*—Through the kindness of Dr. Maidl of the Vienna Museum I have had before me a ♀ example of *X. subjuncta,* determined by Vachal, from Ikutha, East Africa. Though very close, it is not the same as the type of *X. bicarinata.* In the latter the clypeus has a well-marked elevation at the middle of its length, while in *X. subjuncta* there is only a very slight elevation considerably below (in front of) the middle, at about one-third the length from the front margin. The puncturation on the vertex and on the abdominal tergites is much closer in *X. bicarinata,* and the hairs on vertex and thorax are much browner, while in *X. subjuncta* they are almost black.

The hairs on the outside of the legs and basal segments of the tarsi are all black in *X. subjuncta*, while in *X. bicarinatu* some yellow hairs are mixed with the black on the basal segments of the tarsi, as described above. The wings have much more violet sheen in *X. subjuncta*, but this may be due to the specimen having been fresher when captured. Even if *X. bicarinata* eventually proves to be the same species as *X. subjuncta*, it is at any rate a distinct form.

Herr Alfken rightly considers *X. subjuncta* distinct from *X. fraudulenta*, Grib. The British Museum has a series of the last named, including several examples determined by Friese. Though the size varies, all the specimens of *X. fraudulenta* are larger and longer than either *X. subjuncta* or *X. bicarinata*. The median frontal keel is longer in proportion, and the short transverse ridges present on either side immediately in front of the lateral ocelli in *X. subjuncta* are absent in *X. fraudulenta*. The clypeus has no tubercle or elevation on its surface in *X. fraudulenta*, but its hind margin forms an elevated ridge, instead of being flat and impressed on either side as in the other two species. The puncturation of the abdominal tergites is closer in *X. fraudulenta* than in *X. subjuncta*, the knee-cap on the hind tibia is much shorter, extending less than half the length from the base; the hairs on the outside of the legs and basal segments of the tarsi are black with no admixture of yellow.—H. S.]

Xylocopa (*Mesotrichia*) *flavorufa*, De Geer, 1778; Friese, 1915, p. 271.

Loc. ABYSSINIA: Jem-Jem Forest, *ca.* 8000 ft., and between Jem-Jem and Wouramboulchi, 8000–9000 ft., ix–x.1926, 1 ♂, 3 ♀ (*Scott* and *Omer-Cooper*). Friese records the typical form from Eritrea and Somaliland, and certain named varieties from Abyssinia. The species is widely distributed in tropical Africa.

Xylocopa (*Koptorthosoma*) *schoana*,* Enderlein.

Xylocopa schoana, Enderlein, ♀, 1903, Berlin. ent. Z., **48**: 46.
Xylocopa shoana, Friese, ♀, 1909, p. 254; *id.*, 1915, p. 272.

The ♀ sex, on which alone this species was described, closely resembles superficially that of the widely distributed African form known as *X. caffra*, L. After careful comparison of several examples of *schoana* from Abyssinia with specimens of *caffra* from various parts of Africa, it appears that the only reliable external differentiating characters are (i) the colour of the hairs on the sides of the thorax (below the wings and between the front and middle legs), which are bright yellow in *schoana* but black in *caffra*, (ii) the absence of the invaginated chitinous pouch on the front face of the first abdominal segment in *schoana*, while this pouch is present (and inhabited by commensal mites) in *caffra*.†

Some ♂ examples from Abyssinia are referred to this species with reservation, as the limits between *schoana* and *caffra* in this sex are uncertain. The Abyssinian specimens vary among themselves, the hairs being paler in some, more reddish-yellow (especially on the hind part of the abdomen, which has some black hairs at the apex) in others; in some specimens the hairs on the inner side of the legs are mostly black, in others lighter (reddish-brown to

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* The name was spelt thus in the original description, but "*shoana*" in Friese's work.

† [I am indebted to Miss Norma Leveque for pointing out to me the absence of the mite-pouch in *X. schoana*. A groove and depression are present at the place where the opening of the pouch should be, a condition which Miss Leveque states to be always existent in the few species of this subgenus which have no pouch (see N. Leveque, 1930, Amer. Mus. Nov., **434**: 1). It seems that those few species may have been separately derived from normal members of the subgenus by secondary loss of the pouch.—H. S.]

yellow). But all agree in having dark hairs mixed with the yellowish hairs on the front and top of the head, and the scape of the antennae light yellowish beneath, with the distal segments also more or less yellowish beneath, excepting the short second segment and the basal three-quarters of the third, which are dark. In all the specimens the clypeus has a transverse yellow marginal stripe but no longitudinal stripe, whereas in those placed under *caffra* in the British Museum there is usually a median longitudinal yellow stripe as well, sometimes united with the marginal stripe, sometimes starting just behind it (the thick covering of yellow hairs makes it easy to overlook the longitudinal stripe). But this difference is apparently not quite constant, as some ♂ examples from other parts of Africa resemble the Abyssinian ♂♂ in having no longitudinal stripe. Thus, there are in the British Museum two ♂♂ from Ruwenzori (*Scott Elliot*), one (from 9000 ft.) with no longitudinal stripe, the other (from an altitude between 6000 and 8000 ft.) with a longitudinal stripe.

The genital armatures of two Abyssinian examples have been examined, and for comparison those of two specimens, respectively from Ruwenzori and Cape Town, placed under *caffra.* The armatures resemble those figured by Maidl under the names *X. leucothorax* and *X. pseudoleucothorax* (1912, Ann. Naturhist. Hofmus. Wien, **26** : 278, 283), but show certain differences and, until a larger material can be studied and the identity of the true *caffra* ♂ settled, the limits between the two forms in the ♂ sex must remain uncertain.

Friese states (1909, p. 219, under No. 33 in the key) that in *X. schoana* ♀ the head is almost broader than the thorax. This is incorrect, and Enderlein says nothing about it in the original description, but calls attention much more to the fact that *X. inconstans*, F. Smith, has a strongly swollen head in contrast to *X. schoana.*

Loc. ABYSSINIA : Addis Ababa, *ca.* 8000 ft., and Jem-Jem Forest, 8000–9000 ft., ix. and x.1926, 3 ♀ (*Scott*). The British Museum also contains two ♀, respectively from Metcha and the Akaki River, x. and xi.1904 (*Zaphiro*). Enderlein's original record was also Addis Ababa (*Expedition of Freiherr von Erlanger*). The ♂ examples doubtfully referred to this species are : 2 from Jem-Jem Forest, ix.1926 (*Scott*), 1 from the Akaki River, x.1904 (*Zaphiro*) and 1 from Addis Ababa (*Stordy*).

The typical form of *X. caffra* evidently occurs in Abyssinia as well as the subspecies *schoana*, since the British Museum contains 3 typical ♀♀, with black hairs on the pleurae, 2 from Maraquo, v. and xi.1914 (*Kovacs*) and 1 labelled " Zegi Tsana, v.–vi.1902 (*Degen*)." But *X. caffra* is not included by Friese in his list of Abyssinian bees published in 1915.

TETRALONIA, Spin.

Subgenus EUCARA, Friese.

Anthophora, subgenus *Eucara*, Friese, 1905, Z. Hymenopt. Dipterol. 5 : 241, footnote; *id.*, 1909, p. 282.

Eucara was proposed by Friese as a subgenus of *Anthophora*, but the nature of the venation and the form of the pollen-brush in the ♀ necessitate its being treated as a subgenus of *Tetralonia.* The three cubital cells are, as in typical *Tetralonia*, of unequal size, while in *Anthophora* they are of equal size. The third cubital cross-vein is angled as in *Tetralonia*, while in *Anthophora* it forms an even curve. The pollen-brush of the ♀ is formed like that of *Tetralonia macroglossa*, Ill. (*malvae*, auct., *nec* Rossi).

While *Eucara* can in no case be regarded as a subgenus of *Anthophora*, it would be understandable if the particular species dealt with below were placed in a separate genus, since it diverges very much from the typical species of *Tetralonia* in the form of its head and mandibles.

Tetralonia (*Eucara*) *macrognatha*, Gerstaecker.

Eucera (*Tetralonia*) *macrognatha*, Gerst., 1871, Arch. Naturg., 37, (1): 349; *id.*, *in* von der Decken, 1873, Reisen in Ost-Afrika, Gliederthiere, p. 318.
Anthophora (*Eucara*) *macrognatha*, Friese, 1909, p. 283.

Only the ♂ of this species has hitherto been described. The ♀ sex is as follows:—Length, 12–12·5 mm. Black, the chitinous integument of the abdomen with more or less yellowish-red tinge. Head short, broader than long (when the labrum is left out of account). Mandibles long, sickle-shaped, yellowish-red in the middle part, a little excised at the apex. Labrum very closely covered with long, nearly erect hairs, reddish in the middle, greyish-white on the rest of the surface, which is closely and rugosely punctured; the hairs are stout and finely feathery. Clypeus thinly covered in the middle, more closely at the sides, with similar but more decumbent hairs. Cheeks and temples very closely covered with white hairs. Frons with bushy outstanding grey hairs, with a yellowish tinge. Vertex with outstanding straw-yellow hairs. Antennae with scape reddish-brown beneath and with second segment of funicle somewhat shorter than the three following together. Mesonotum rather closely punctured, feebly shining, closely covered with yellowish-brown hairs. Pleurae and sternum covered with greyish-yellow hairs, the former with some black hairs behind. Sculpture of scutellum, postscutellum and propodeum not clearly discernible on account of the thick hairs. Abdominal tergites yellowish-brown, the basal parts narrowly black, with a felt-like covering of close, short, decumbent hairs, the third and fourth tergites also furnished ventro-laterally with some few longer bristle-hairs. Hind margin of fifth tergite lighter yellowish-brown, covered with white hairs at the sides. Apical tergite black, with a shallow transverse depression, which is feebly grooved and finely margined on either side, the lateral parts of the tergite covered with bright rust-red hairs. Ventral side of abdomen black, the sternites each with a broad, yellowish-red, depressed hind margin, the black basal part with some hair-bearing punctures, and with long outstanding bristly hairs on either side in front of the depressed hind margin. Femora, tibiae and tarsi more or less red-brown; middle and hind tarsi with black hairs on the outer side, the middle pair also with black hairs on the inner side; front tibiae and tarsi with whitish hairs on the outer side, front and hind tarsi partly covered on the inner side with rust-red hairs; hind tibiae loosely covered on the outer side with black hairs; penicillus rust-red; spurs light reddish-brown. Wings faintly clouded, veins and stigma blackish-brown, the latter translucent in the middle; tegula straw-yellow, without shine, closely and finely reticulate.

Loc. Central Abyssinia: Maraquo, xi.1914, 1 ♂, 2 ♀ (*Kovacs*). The original locality was Mombasa, ix.1862. Friese adds simply "Ostafrika."

Heriades, Spinola.

Heriades argentatus, Gerstaecker, 1857; Friese, 1909, p. 313 *; *id.*, 1915, p. 274.

Loc. Abyssinia: Jem-Jem Forest, nearly 9000 ft., 24.ix.1926, 1 ♀ (*Scott*). The original locality was Tette in Mozambique. Friese records it from Kilimanjaro, and Ghinda in Eritrea.

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* The reference by Friese to Peters, 1862, Reise Mossambique, Vol. V, should read p. 449, *not* p. 469.

MEGACHILE, Latreille.

Many species have been recorded from Abyssinia, particularly in Friese's 1915 paper, p. 274. Two were collected by the expedition under review, but one of them (a form somewhat resembling the East African *M. felina*, Gerst.) must remain unnamed at present. Notes on two other species, including new Abyssinian records, are added.

Megachile abessinica, Friese, 1915, pp. 275, 293.

Loc. ABYSSINIA: Jem-Jem Forest, *ca.* 8000 ft., between 22 and 26.ix.1926, 1 ♂, 1 ♀ (*Scott*); Maraquo, xi.1914 (*Kovacs*); the original record was Harar, both sexes plentiful in November (*Kristensen*).

Megachile janthoptera, F. Smith, 1853; Friese, 1915, p. 275.

Loc. ABYSSINIA: Maraquo, xi.1914, 2 ♀ (*Kovacs*); Holota, a little west of Addis Ababa, 1 ♀ (*Zaphiro*); Harar, 1 ♂, taken in November (*Kristensen*). Widely distributed in Tropical Africa, west and east, and extending to South Africa.

Megachile barbata, F. Smith, 1853; Friese, 1909, p. 366.

This species does not appear to have been recorded from Abyssinia before. The examples mentioned below agree with the type.

Loc. ABYSSINIA: Higo Samula, 30.x.1911, 1 ♀, and a second ♀ without exact locality (*Stordy*). The original locality was South Africa, and the British Museum also has specimens from Nyasaland and N.E. Rhodesia.

CHALICODOMA, Lepeletier.

Though the species cannot at present be identified, some geographical interest attaches to the capture of a single ♂ on the summit of Mt. Zukwala, *ca.* 9000 ft., between 21 and 25.x.1926 (*Scott*). It was doubtfully referred to *C. aduaënsis*, Friese (*Megachile* (*Chalicodoma*) *aduaënsis*, Friese, 1909, pp. 327, 377), a species described in the ♀ sex only from examples collected by Kristensen in Eritrea. But Dr. Bischoff, after comparing the Zukwala ♂ with the type of *aduaënsis* at Berlin, considers that the two do not belong to the same species.

MELIPONA, Illiger.

Several species have been listed from Abyssinia; see (under *Trigona*) Friese, 1915, p. 276. In the collection under review the genus is represented by one species, previously recorded from Mount Elgon. Three forms of it are defined below, two based on Abyssinian examples and one on specimens from Ruwenzori.

Melipona alinderi, Alfken, 1929, Konowia, **8**: 475.

Typical form.

☿: first abdominal tergite black or marked laterally with yellow at the base.

Loc. ABYSSINIA: between Jem-Jem Forest and Addis Ababa, 7000–8000 ft., 11–14.x.1926, 1 ☿ (*Scott*); upper edge of Jem-Jem Forest, *ca.* 9000 ft., 4.x.1926, 3 ☿ (*Scott*); Gatelo Amaiyu, 4.xi.1911, 2 ☿ (*Stordy*).

Var. **nigrita**, var. n.

☿: abdomen and legs quite black. This form shows, like the preceding, an ill-defined yellowish line along the inner margins of the eyes, by which *M. alinderi* can be clearly distinguished from *M. beccarii*, Grib., in which the line is sharply defined.

Loc. Abyssinia : Jem-Jem Forest, *ca.* 8000 ft., 22 or 23.ix.1926, 8 ☿ (*Scott*); the same forest, nearly 9000 ft., 24.ix.1926, 1 ☿ (*Scott*); upper edge of the same forest, *ca.* 9000 ft., 4.x.1926, 3 ☿ (*Scott*).

It thus appears that these two subspecific forms occurred not merely in the same locality, but were flying on the same day (4.x.) in one spot at the upper forest-edge.

Subsp. **mimica,** subsp. n.

☿. First abdominal tergite with a large yellow mark on either side; second tergite with a yellow stripe interrupted in the middle; third tergite with a more or less extended yellow mark on either side. This colouring somewhat resembles that of the ♂.

Loc. Ruwenzori : the type of this subspecies is from between 7000 and 8000 ft., and another example was taken at 9000 ft.; but two other specimens, respectively from 5600 ft. and between 6000 and 8000, have the abdomen almost entirely black and should probably be referred to the form *nigrita* (all collected by *G. F. Scott Elliot*, 1895).

Apis, L.

Apis mellifica, L., subsp. *unicolor*, Latr.

The specimens collected (all workers) are all referable to the subspecies *unicolor*, but to two distinct forms of it, namely var. *unicolor*, s. str. and var. *adansoni*, Latr. Some examples obtained by Kovacs are referred to a third form of the same subspecies, namely var. *intermissa*, Buttel-Reepen. The localities are as follows :

Var. *unicolor*, s. str. Jem-Jem Forest, *ca.* 8000 ft., ix.1926, 6 ☿; cultivated country near Addis Alam, *ca.* 8000 ft., ix.1926, 1 ☿; Doukam, *ca.* 7000 ft., x.1926, 1 ☿; Mt. Chillálo, from short turf dotted with bush-heath (*Erica arborea*), *ca.* 10,000 ft., xi.1926, 1 ☿ (all *Scott*). Recorded by Friese * from West Africa, Madagascar and the Mascarene Is.

Var. *intermissa*, Buttel-Reepen. Maraquo, 7.v.1914, 2 ☿ (*Kovacs*). This form is recorded from the Mediterranean and many parts of Africa.*

Var. *adansoni*, Latr. Doukam, *ca.* 7000 ft., x.1926, 1 ☿ (*Scott*); Maraquo, 7.v.1914, 3 ☿ (*Kovacs*); recorded by Friese † from Harar, isolated ☿☿ taken in November (*Kristensen*). Somaliland, Tropical Africa, etc.

[*Translator's Note.*—The specimens which I collected were all captured flying in the open, none were taken from hives. Bee-keeping was not much in evidence in the wild and sparsely-populated places visited by the expedition, but it is extensively practised in parts of the country where the supply of wild honey is not enough. Honey is greatly in request for making the national drink, *tej*, *i.e.* mead. The beehives are cylindrical, 4 feet or more long by 1 or 2 feet in diameter, made out of hollow tree-stems or basketwork. They are hung up in trees or under the thatched eaves of houses, or are kept inside the houses, in which cases holes are made in the house wall for the bees to pass in and out. An interesting account is given by A. B. Wylde, 1901, *Modern Abyssinia*, chap. xi., pp. 279–281. Wylde mentions the large trusses of white flowers of the *wanza* tree (*Cordia abyssinica*) and the little white flowers of the tree-heath (*Erica arborea*) as specially attractive to bees.]

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* 1909, p. 459.

† 1915, p. 276.

THE PLUME-SCALES OF THE PIERINAE

By F. A. Dixey, M.A., M.D., F.R.S., Hon. Fellow of Wadham College, Oxford.

[Read 2nd March, 1932.]

With 437 Text-figures.

The Presidential Address given by the present writer in January, 1910, and published in the *Proceedings* of the Society for 1909, contained a general account of the plume-scales which are found in the males of many Pierine genera, together with descriptions of the appearances presented by these structures in a large number of those forms that possess them. The Address was accompanied by outline figures of the plumules of some 22 species, and a few figures of representative forms drawn in greater detail on a larger scale. It is now proposed to give outline figures of the plume-scales of all such Pierine forms as are readily accessible in the Hope Collection at Oxford.

The general facts relating to the structure and distribution of these scales, and their significance as factors in determining questions of affinity, having been dealt with in the Address above referred to, it appears to be needless to recapitulate the account there given. It will be found that some discrepancies occur between the descriptions in the Address and the figures now presented. These differences are usually due to the fact that in every case the figure is the copy of an actual scale, and that individual variations occur even in scales taken from the same specimen; they thus serve to illustrate the principle that generalisations founded on single or even a few instances are liable to error. It is believed, however, that the discrepancies are not of great importance. It may further be noted that the figures not being diagrammatic, but representations of actual specimens, the outline of the disc varies according to the angle at which it is seen in the preparation. With regard to the figures, I am well aware of my deficiencies as a draughtsman, and I confess to finding it much more difficult to get a good result with pen and ink than with pencil. Still I venture to think that my figures, such as they are, will suffice for the purpose in view. It should be noted that they are drawn to the same scale, giving a magnification of about 130 diameters, so that their comparative dimensions are seen at a glance. In a few instances, specially noted in their place, the magnification is somewhat less. In the Address above referred to, I used for the sake of uniformity the generic names at that time employed in the collection of the British Museum. This arrangement has since been somewhat modified, and I have consequently adopted the names as they now stand in that collection. It will I think be allowed that a paper of this kind is not the place for an attempted revision of genera, and the importance of a definite and accessible standard is evident.

For the development of the scent-scales from specialised hypoderm cells, reference may be made to 1931, *Trans. Ent. Soc. Lond.*, **79** : 384, fig. 12; and for the relation of lamina, footstalk and accessory disc with its proximal aperture, in a species of *Pinacopteryx*, to 1919, *Trans. Ent. Soc. Lond.*, **1919** : 383–390, pl. xvi. It should be noted that I am now much inclined to doubt whether the fimbriae of the plume-scales are pervious, as was supposed by Weismann. The appearance of a terminal orifice which is often to be seen in a fimbria turned up towards the observer seems to be merely the effect of a transparent rod in optical section; while there can be little doubt that, as stated by Illig,* the fimbriae are prolongations of the longitudinal ribs of the scale. I am, moreover, inclined to doubt whether the columns of fluid that can be seen at different levels between the longitudinal ribs of a moistened scale are within the scale. It seems to be more likely that they lie outside the scale, between the lines which a transverse section shows to be an external ribbing of the upper surface.

The species of *Ixias* are furnished with plume-scales, triangular in *pallida* and *marianne*, rather long and narrow with slight lateral compression and basal expansion in the rest. In all the accessory disc is rather small, oval or circular (figs. 1–9).

The genus *Teracolus* (figs. 10–59) falls naturally into sections, two of which have sometimes received the generic names *Idmais* and *Callosune*. The *Idmais* section, comprising *T. fausta*, Oliv., *T. phisadia*, Godt., *T. calais*, Cram., etc., have no plume-scales, but are furnished with specialised scales of a different appearance, collected into "sex-brands."

In *T. subfasciatus* and its northerly form *T. ducissa*, the plume-scale is very like that of *Ixias* and the disc is small. In the African purple- and maroon-tips the plume-scale is also like that of *Ixias*, but the disc is remarkably large. The scale of *T. mananhari* from Madagascar is similar to these, and that of *T. elgonensis* is of the same character, though rather longer, and showing a greater contrast between the broad proximal and narrow distal portion of the lamina. The scale figured is from the hind-wing; in this specimen the fore-wing appeared to be destitute of plume-scales. A difference in size is apparent between the scales from fore- and hind-wing in *T. ludoviciae*. A scale (fig. 20) from the same specimen (fore-wing) is unlike all the rest, and is perhaps only accidentally present in the preparation. Its disc, however, is not exceptional in the group.

The plume-scales of the crimson-tipped group, *T. annae*, *T. eupompe*, *T. dulcis* and *T. guenei*, differ from those of the purple-tips by the smaller size of the accessory disc. They are also generally broader in proportion to their length. The scale in *T. danae* is smaller than in the rest.

Among the orange-tipped *Teracolus* it is remarkable that I have never been able to find plume-scales in *T. incretus*, Butl., or *T. auxo*, Luc., though I know from my own observation that *T. auxo* has a fragrant odour. Both *T. evarne* and *T. phillipsi*, however, possess plume-scales, rather long and narrow with small discs. In the two last-named, with *T. evenina*, many of the ordinary scales of the orange patch have a lateral curvature with rounded distal border and no indentations. The plume-scale in *T. eucharis* is similarly long and narrow, with a small disc. In another orange-tipped group, comprising *T. evagore*, *T. evippe*, *T. infumatus*, *T. aldabrensis*, *T. niveus*, *T. omphale*, *T. achine* and *T. evanthe*, the scale is of the same general character with that of *T. evarne* and *T. phillipsi*, but possesses a larger accessory disc. In *T.*

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* 1902, "Duftorgane der männlichen Schmetterlinge," *Zoologica, Stuttgart*, **15**. Illig takes as his chief example of a plume-scale the scale of "*P. napi*." But it may be noted that his "*P. napi*" is really *P. brassicae*, as is evident from his figure, Taf. I, fig. 1, and also from his remarks on the character of the scent. Illig has a good bibliography up to the date of his paper.

evagore the scale of the dry season form is broader than that of the wet, and tends to expand at the base. The plume-scale of *T. niveus* is comparatively small; that of *T. aldabrensis* is large. In *T. achine* the apex is often especially sharp, and in *T. omphale, T. achine, T. infumatus* and *T. evanthe* the footstalk in preparations is generally straight.

In *Teracolus lais* the disc is large; in *T. rogersi, T. ephyia* and *T. daira* it is moderate in size; in *T. etrida, T. xantholeuca, T. evenina* and *T. casta* it is small. *T. agoye* has a rather long and narrow scale expanded at the base; the disc is large. In *T. halimede, T. heliocaustus, T. pleione,* the disc is unusually large; in *T. chrysonome, T. vesta* and *T. protomedia* it is larger still, with a peculiar chitinous framework best seen in *T. protomedia.* In *T. celimene* the plume-scale recalls that of the crimson-tips. The scale in *T. eris* is somewhat like that of *T. elgonensis*, but is still longer and narrower; it has an unusually long footstalk. The plume-scale of *Herpaenia eriphia* (fig. 60) is of similar character, but rather broader and shorter.

The scent-scales in *Hebomoia* (figs. 61–69) bear a general family resemblance. They are large, with a moderate-sized disc; they are rather long in proportion to their width, and have a basal expansion like that in several species of *Ixias* and *Teracolus.* It is observable that they are often unsymmetrical, the lamina being more concave on one side than on the other. The chitinous ribs of the lamina converge towards the footstalk; not, as in *Pieris rapae*, etc., keeping the same direction till they reach the base of the scale. The Madagascar form *Ptychopteryx lucasi* (fig. 70) appears to be allied to the *Eronia* group, but its scent-scale is peculiar. The lamina is somewhat slug-shaped, expanding proximally; the base ends in two thin, sharp-pointed projections inclined towards one another and occasionally overlapping. The footstalk passes between them to a large, clear, broadly elliptical disc. The apex is shallow and the fimbriae short.

Of the *Eronia* group, the plume-scales (figs. 71–84) of the genus *Pareronia*, the distribution of which is wholly Eastern, have also a general family resemblance. The lamina in all the species is long and narrow, the sides in some forms being nearly parallel, in others tapering more or less gradually towards the apex, which is always sharp. The disc is usually small, but in some of the island forms it is comparatively large; in it a circular orifice is often visible. In several species a clear area is to be seen near the distal end of the lamina, bounded by a densely granular region both distally and proximally. The distribution of the scent-scales on the surface of the wing is irregular; they are most numerous near the border of the hind-wing, giving the appearance of a sex-brand. An exception to this feature is furnished by *P. avatar*, whose scent-scales, smaller than those of its congeners, and broader than most of them in proportion to their length, are distributed over the general surface of the wing.

In *Nepheronia* (figs. 85–88), the species of which genus are entirely African, the scent-scales, as in the preceding genus, tend to be collected within definite areas of the wing. The slight depression at the outer end of the cell of the hind-wing is the situation where they are most certainly to be found. In the southern form *varia*, Trim., of *N. argia*, Fabr., they appear to be restricted to this spot; but in forms of *N. argia* from West, Central and East Africa they are distributed over the general surface. The plume-scale in *N. thalassina* is small; in *N. argia* the base ends in incipient cornua, more pronounced in the Western than in the Southern form. In *N. pharis* the lamina is very narrow, and the base shows pronounced expansion and marked cornuation. The scent-scale in *Leuceronia buqueti* (fig. 89) is broad, with sides almost parallel, a rather blunt apex and short fimbriae. In all these species of *Nepheronia* the disc is large; it is still more so in *L. buqueti*. The two species of *Eronia* proper (figs. 90–91) have plume-scales differing from those of the two preceding genera by their smaller size and also by their distribution, being scattered generally over the wing, and not collected into definite areas. The sides of the lamina in *E. cleodora* are parallel and the base rounded. In *E. leda* the base shows incipient cornua.

The plume-scales in *Euchloe* (figs. 92–103) and *Zegris* (fig. 104) are fairly uniform in appearance. It is remarkable that they appear to be absent from *E. scolymus*, Butl., *E. euphenoides*, Stdgr., and from the fore-wing of *E. sara*, Luc. Scent-scales seem also to be wanting in *Z. eupheme*, Esp., unless certain scales somewhat like those of *E. belia*, but without either disc or fimbriae, may be taken as such. A feature common to all the species is the small size of the disc; this is especially noticeable in *E. cardamines* and *E. belemia*. In several of the forms, as *E. genutia*, *E. tagis* and *E. belia*, the distal edge of the lamina is blunt and rounded. The prolongation of the longitudinal bars of the lamina into the fimbriae is well seen in *E. cardamines* and *E. belia*. The remarkable Chilian orange-tip *Eroessa chilensis* (fig. 105) has a plume-scale like that of a *Euchloe*, but much larger than that of any *Euchloe* known to me.

Plume-scales of much the same character as those of *Euchloe* are seen in *Hesperocharis* (figs. 106–116). The sides of the lamina are usually parallel and the base rounded. The disc is small, and the apex usually sharper than in *Euchloe*, the lamina is also generally broader in proportion to its length. The plume-scale of *Mathania agasicles* (fig. 115) is like that of a *Hesperocharis*.

The scent-scales in *Daptonura* (figs. 117–121) are peculiar. They have no disc, but end proximally in a footstalk like that of an ordinary scale. The distal extremity is rounded, truncate or bilobed. Fimbriae, few in number, are found on each side of the distal end, but not quite at the summit. In some species a triangular membrane is occasionally visible, connecting each fimbria with the body of the scale. These scales are confined to the male sex; they are found abundantly on the upper surface of the wing, and by their general character they recall the hair-scales which occur commonly in species of Lepidoptera.

In the genus *Pinacopteryx* (figs. 122–134) the plume-scales of all the species present the character of an expanded base. This may be rounded or angulated, and occasionally globular. In *P. liliana* the neck of the flask-shaped lamina has a decided list. The disc in all the species is large.

The genus *Belenois* (figs. 135–161) has scent-scales which are, with a few exceptions, fairly uniform in character. The most remarkable of these exceptions is that afforded by *B. gidica*, a species which not only by its scent-scales but also by its genitalia shows marked differences from the forms with which it is usually associated. The distal tubercles in place of fimbriae, the extremely small disc, contrasting with the large disc of the rest of the genus, suggest a comparison with the peculiar scent-scale of *Daptonura*. The plume-scale of *B. antsianaka* from Madagascar is remarkable for its large size, its hastate outline and its cornuated base. A somewhat similar character is shown by the much smaller plume-scales of *B. ianthe* and *B. solilucis*. The sides of the lamina in some species, as *B. thysa*, are parallel, but in most of the others are slightly sinuous.

The scent-scale in the somewhat isolated form *Leuciacria acuta* (fig. 162) from New Guinea is like that of several of the New Guinea *Delias.*[*] In *Delias* itself (figs. 163–232) the plume-scales vary much in size and shape, but in all cases taper more or less gradually from an expanded base to an apex which is always comparatively narrow, and in many species filiform. The disc may be large, as in the *D. eucharis* group; but in several species it is small.

In *Delias euphemia*, *D. mysis* and *D. lara* the lamina is small and triangular with an apex prolonged and somewhat broader than is usual in this genus. The disc is large. In several species, such as *D. heroni* and *D. albertisi* the lamina is exceptionally long and narrow.

In *Delias microsticha* the plume-scales again are extremely long and narrow. The disc is small. The corresponding scales in *D. argenthona*, *D. caeneus*, *D. eucharis*, *D. stolli*, *D. hierte*, *D. hyparete* and *D. nyasana* are like each other in character, and recall those of *D. mysis* and *D. lara.* As in those forms, the disc is large. In the *belisama* group the disc is larger still.

In the group headed by *Delias pyramus* the lamina is moderate in size, but the disc is generally large. The lamina in *D. belladonna* is like that in *D. agostina*, but tapers more gradually to the apex.

It was noticed by Watson [†] that no plume-scales are to be found in the Eastern genus *Prioneris*, the species of which offer a remarkable resemblance to some of those of *Delias.* This observation of Watson's was mentioned by Wallace in his paper on the Eastern *PIERINAE*.[‡]

With the neotropical genus *Pereute* (figs. 233–241) we come upon a different kind of plume-scale, characterised by a rather narrow lamina with a blunt apex and a base furnished with sharp-pointed cornua, generally very long and often unsymmetrical. The disc, usually moderate in size, is rather large in *P. antodyca*; in which species the lamina is comparatively broad and the sharply-pointed cornua are curved like claws.

In *Leodonta* (figs. 242–245), which genus has a neuration like that of *Pereute*, the plume-scales are of a similar character, but with the lamina shorter and broader in proportion. The base of the lamina is unsymmetrically cornuated, but the cornua are generally shorter than in the preceding genus.

A common type of plume-scale prevails throughout the members of the genus *Catasticta* (figs. 246–270), but many specific differences are recognisable. The base is sometimes cornuated, generally unsymmetrically. The lamina is as a rule broad in proportion to its length, sometimes, as in *C. flisa*, extremely so. *C. corcyra* and *C. anaitis* in this respect are exceptional. The disc is small in *C. pinava* and *C. bryson*, large in *C. sisamnus* and *C. theresa.*

The plume-scales in *Archonias* (figs. 271–278) are quite unlike those in *Pereute*, *Leodonta* and *Catasticta.* They are long and narrow, with the sides of the lamina passing gradually into a stout footstalk and moderate-sized disc. The distal border is straight or very slightly convex. The fimbriae in *A. negrina* are very short, in *A. rosacea* they are longer than in the other species of *Archonias.*

In all the species of *Leptophobia* (figs. 279–288) the disc is represented by a scarcely perceptible expansion of the footstalk; the base of the lamina is sometimes slightly cornuated. In *L. penthica* the plumules are plentiful in the black area of the wing, but appear to be scanty in the white.

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[*] For an account of the important and interesting genus *Delias,* see the excellent Monograph by Mr. G. Talbot of the Hill Museum, Witley, now in course of publication.

[†] 1868, *Mem. Lit. Phil. Soc. Manchester,* (3), **3**: 259, 260. Watson also found no plume-scales in *M. agathon*, *P. protodice* and *P. callidice.*

[‡] 1865–1868, *Trans. Ent. Soc. Lond.*, (3), **4**: 383.

In *Itaballia* and a section of *Pieris* (figs. 289–297) containing *P. viardi*, *P. locusta* and their immediate allies, the disc, instead of being minute as in *Leptophobia*, is moderate in size, in *I. pylotis* large. In many of the species the proximal orifice of the disc is very distinct; it may have a chitinous rim. In *P. phileta*, which perhaps belongs to this section, the scale is comparatively large; the lamina narrows towards the base, which is rounded. The disc has an evident aperture (fig. 306).

In *Pieris* (figs. 298–305) we also meet with an entirely different type of scent-scale from those that have just been noticed. These scales are exceedingly long and narrow, somewhat recalling those of several species of *Delias*, but differing from the latter in the character of the disc, which is as small and inconspicuous as the corresponding structure in *Leptophobia*. In this group the scent-scales are not evenly distributed over the wing, but are found in great abundance in certain roughened or mealy streaks, easily visible to the naked eye, which follow the course of the veins. In some of the species, as *P. phaloe*, the sides of the lamina taper gradually from the base up to about the last quarter of the distance from base to apex; from this point the sides run nearly parallel. In other species, as *P. buniae*, the sides taper more uniformly towards the apex. The distal extremity in this species is not so narrow as in the rest of the section. The scent-scale of *P. josepha* is the longest known to me; but those of *P. janeta* and *P. howarthi* run it close.

The plume-scales of a group of neotropical Pierines (figs. 306–310) associated by Butler, on the strength of their neuration, with the very distinct African genus *Mylothris*, but now generally known as *Perrhybris*, resemble those of *Itaballia* and the *viardi* section of *Pieris*. As in these latter forms, the proximal aperture of the disc is often conspicuous.

The remarkable scent-scales of the African species of *Mylothris* (figs. 311–326) are quite distinctive. For a detailed account of their structure reference may be made to 1909, *Proc. Ent. Soc., Lond.*, **1909**: cxxi–cxxiii; Pl. D, fig. 3. They invariably show a median constriction, especially well marked in *M. poppea*, *M. spica* and *M. sulphurea*.

In the Australian genus *Elodina* I find no scent-scales; the African species of *Nychitona* appear also to lack them. They are present, however, in the Asiatic *N. xiphia* (fig. 327), in the shape of small scales with long fimbriae, a rounded base, straight footstalk and cylindrical disc. They occur also, but rather scantily, in a co-type of Wallace's *N. dione* (fig. 328), a large form from Celebes.

The scent-scales of the neotropical group of *Appias* (figs. 329–341) typified by *A. drusilla* are of a like character with those of most of the African species of the genus. The males of *A. epaphia* are not readily separable from those of *A. sabina*; the scent-scales, however, give a means of distinction, the base of the lamina being rounded in the latter and almost squared in the former.* A different kind of scent-scale is seen in *A. phaola* and *A. isokani*. In these the lamina tends to be goblet-shaped and the distal margin to be segmental, not angulated; the fimbriae are short, the disc rather large. In *Appias* (*Saletara*) *liberia* there is a well-marked median constriction.

The group headed by *Appias* (*Catophaga*) *celestina* (figs. 342–355) has plume-scales which are remarkable in several respects. They occur sparsely on the fore-wing, but are found abundantly in a patch about half-way along the inner margin of the hind-wing, which patch in some of the species is easily visible on a naked-eye inspection. The scent-scales in this latter situation

* See 1918, *Proc. Ent. Soc. Lond.*, **1918**: clxx–clxxii.

differ conspicuously from those of the fore-wing by the hastate shape of the lamina, the base of which is often slightly cornuated, but notably by the very large size, both relative and absolute, of the accessory disc. The scent-scales of the fore-wing in *C. placidia* are exceptional in being numerous in that situation and in being furnished with long and tapering basal cornua. In the scales from the patch on the hind-wing the basal cornua are much less developed, and the accessory disc is enormously large. In *C. domitia* the difference between the scent-scales of fore- and hind-wing is less than in the other members of the *celestina* group; the disc is comparatively moderate in size and is elongated.

The scales in *A. lyncida*, Cram., *C. nephele*, *A. hombroni*, *Hyposcritia cardena* and *C. ithome* (figs. 356–363) differ from those of the preceding group in having a very small disc, in some cases almost linear. The lamina is long in proportion to its breadth (least so in *H. cardena*) and the base shows a slight cornuation. I have found no scent-scales in *A. ada*, Cram.

The remainder of the *Appias* group of species ranked under the respective heads of *Catophaga* and *Hyposcritia* (figs. 364–375) possess plume-scales of a fairly uniform character. *H. aegis* (fig. 337) no doubt comes into this group. The lamina is moderate in size, the sides nearly parallel or with slight median compression, the disc generally rather small though larger than in the *A. lyncida* group. *Udaiana cynis* (fig. 376) has a scent-scale of similar character, but with a more strongly marked proximal dilatation.

With *Huphina* (figs. 377–405) we enter upon a well-marked genus, numerous in species, Oriental and Australian in distribution. The scent-scales are of the same general character throughout, resembling those of many species of *Delias* and also those of the *phaloe* group of *Pieris*, both in their form and also in their relative abundance. *H. abnormis* and *H. euryxantha*, remarkable for their mimicry of certain species of *Delias*, have scent-scales which are rather exceptional in this genus, being relatively small, with slight lateral compression, and not tapering to a point. Their rounded base and small circular discs are like those in the rest of *Huphina*.

The Central Asian genus *Metaporia*, comprising *M. agathon*, Gray, and its allies, appears to be devoid of plume-scales.

A section of *Pieris* (figs. 406–421), comprising *P. brassicae*, *P. rapae*, *P. napi* and their allies, is well marked off from the remainder of the genus by the character of its scent-scales. The lamina in *P. rapae*, *P. napi*, and *P. canidia* is cordate with the basal cornua strongly marked; it shows an irregularly granular area somewhat like that present in certain species of *Pinacopteryx*, and an almost clear area between this and the apex. The distal portion of the lamina in these species has sometimes a list like that seen in *Pinacopteryx liliana*. *P. brassicae* with its local races stands apart from the rest of the section in some respects. It has a very long scent-scale, with sides tapering gradually from a cornuated base to an apex which is narrow but not filiform. The fimbriae are irregularly disposed, forming a kind of tangle. In some of the forms nearly allied to *P. napi*, e.g. *P. oleracea* and *P. ajaka*, the cornua frequently end in sharp spines. An approximation to this condition is occasionally visible in *P. napi* itself.* A form ranked under *P. melete* has a remarkably large disc. *P. cisseis* from China is noteworthy in having a plume-scale like that of the American genera *Itaballia* and *Perrhybris* rather than that of any Old World species of *Pieris*.

In *Pontia* (figs. 422–431) several of the species, viz. *P. glauconome*, Klug, *P. callidice*, Esp., and *P. protodice*, Boisd.-Lec., appear to be unfurnished with scent-scales. The plume-scales in *P. daplidice*, *P. chloridice*, *P. hellica* and *P. johnstoni* strongly resemble many of those seen in *Euchloe.* I find no plume-scales in either *Baltia* or *Phulia*; in *Tatochila*, however, they are usually present, except in *T. immaculata*, Röber, *T. demodice*, Blanch., and *T. gymnodice*, Stdgr. When present they are not unlike the plume-scales in *Pontia*, though generally larger. These scales in *T. autodice* are unusually broad.

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* See 1916, *Proc. Ent. Soc. Lond.*, **1916**: xlviii–li.

The scent-scales in *Neophasia menapia* (fig. 432) appear to be scanty. They are of the long and narrow type, with a blunt apex and short fimbriae. The base tapers into a footstalk which expands proximally into a small disc.

In *Aporia crataegi* and *A. soracta* (figs. 433–434) the scent-scales are apt to vary in breadth. The sides of the lamina in the former species are usually parallel, in the latter they diverge distally and the distal margin is rounded. In *A. procris* (figs. 435–435′) the sides of the lamina are irregular; in *A. nabellica* (fig. 436) the lamina is rather broad in proportion to its length, and has a slight lateral compression. *A. llamo* (fig. 437) has a scent-scale of similar character, but with sides diverging towards the distal margin. Throughout the genus the fimbriae are comparatively short.

I can find no scent-scales in the gregarious nest-making *Eucheira socialis*, Westw.

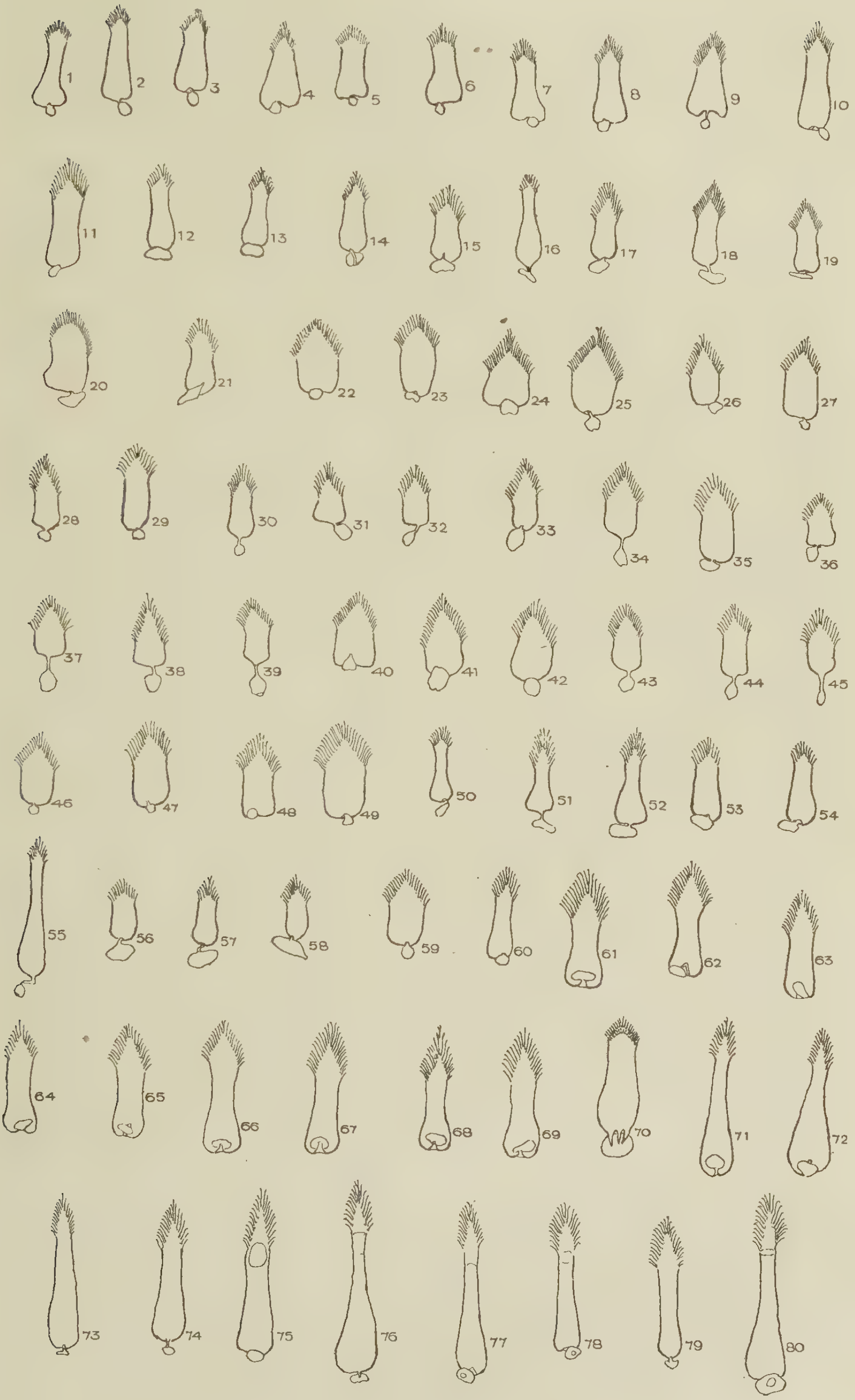
EXPLANATION OF TEXT-FIGURES.

FIGS. 1–9.—1. *Ixias pyrene*, Linn. Delhi. 2. *I. undatus*, Butl. Borneo. 3. *I. andamana*, Moore. Andaman Islands. 4. *I. pallida*, Moore. Siamese Malay States. Jalor: Biserat. 5. *I. flavipennis*, Gr. Smith. W. C. Sumatra. 6. *I. baliensis*, Fruhst. Bali (Wallace's specimen). 7. *I. baliensis*, same specimen. Scale from grey area at base of fore-wing. 8. *I. nola*, Swinh. Mahableshwar. 9. *I. marianne*, Cram. Baliganji?

FIGS. 10–21.—10. *Teracolus subfasciatus*, Swains. S. Africa. 11. *T. ducissa*, Dogn. E. Africa, Tabora, Lulanguru. 12. *T. mananhari*, Ward. Madagascar. 13. *T. phlegyas*, Butl. B.E. Africa, Sabaki Valley. 14. *T. ione*, Godt. (*speciosus*, Wallgrn.). Durban. 15. *T. regina*, Trim. S. Africa. 16. *T. elgonensis*, E. M. Sharpe. Kenya; Kikuyu. Scale from hind-wing; no scent-scales found in preparation from fore-wing. 17. *T. hetaera*, Gerst. Kenya: Taita, Dabida Mountains. 18. *T. hetaera*, Gerst. Kenya: Rabai. 19. *T. ludoviciae*, E. M. Sharpe. Somaliland, Berbera. 20. *T. ludoviciae*, same specimen, abnormal scale. 21. *T. ludoviciae*, same specimen. Scale from hind-wing.

FIGS. 22–39.—22. *Teracolus annae*, Wallgrn. Mashonaland. Dry season. 23. *T. annae* f. *callidia*, Gr. Smith. Kenya: Taita. Wet season. 24. *T. eupompe*, Klug. Arusa Galla Country. Wet season. 25. *T. dulcis*, Butl. Karachi. 26. *T. danae*, Fabr. Nilgiri Mountains. 27. *T. guenei*, Mab. [Madagascar.] 28. *T. evarne*, Klug. V. Nyanza, Kisumu. 29. *T. phillipsi*, Butl. Somaliland. 30. *T. eucharis*, Fabr. Nilgiris, Conoor. 31. *T. evagore*, Klug. Dry season. 32. *T. evagore*, Natal. Wet season. 33. *T. evippe*, Linn. W. Africa. 34. *T. infumatus*, Butl. N.E. Rhodesia. 35. *T. aldabrensis*, Holland. Aldabra. 36. *T. niveus*, Butl. Sokotra. Dry season. 37. *T. omphale*, Godt. Zanzibar: Wasin. 38. *T. achine*, Cram. Mashonaland, Salisbury. 39. *T. evanthe*, Boisd. Madagascar.

FIGS. 40–60.—40. *Teracolus liagore*, Klug. White Nile, El Duêm. 41. *T. lais*, Butl. Bechuanaland. 42. *T. rogersi*, Dixey. Kenya, Taveta. Bred. Scale from type. 43. *T. ephyia*, Klug. Khartum. 44. *T. daira*, Klug. Shaik Othman. Wet season. 45. *T. etrida*, Boisd. Karachi. 46. *T. xantholeuca*, E. M. Sharpe. Kenya: S. Kavirondo. 47. *T. evenina*, Wallgrn. Mashonaland. 48. *T. casta* f. *sipylus*, Swinh. N.E. Rhodesia. Wet season. 49. *T. casta*, Gerst. Kenya: Taveta. 50. *T. agoye*, Wallgrn. Matabililand. Oates specimen. 51. *T. halimede*, Klug. Aden. Dry season. 52. *T. halimede* f. *leo*, Butl. Kenya: Taita. Wet season. 53. *T. heliocaustus*, Butl. Somaliland. 54. *T. pleione*, Klug. Aden. 55. *T. eris*, Klug. Somaliland. 56. *T. chrysonome*, Klug. V. Nyanza. 57. *T. vesta*, Reiche. Mombasa. 58. *T. protomedia*, Klug. Shaik Othman. 59. *T. celimene*, Luc. V. Nyanza. 60. *Herpaenia eriphia*, Godt. Arusa Galla Country.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Text-figs. 1–80.

Figs. 61–91.—61. *Hebomoia glaucippe,* Linn. Singapore. 62. *H. javanensis,* Wallce. E. Java. 63. *H. borneensis,* Wallce. British N. Borneo. 64. *H. philippensis,* Wallce. [Philippine Islands.] 65. *H. celebensis,* Wallce. Celebes: Minahasa. 66. *H. leucogynia,* Wallce. Bouru. 67. *H. leucippe,* Cram. [Amboyna, Ceram.] 68. *H. roepstorfi,* Wood-Mason. Andaman Islands. 69. *H. vossi,* Maitland. Nias. 70. *Ptychopteryx lucasi,* Grand. Madagascar. 71. *Pareronia pingasa,* Moore. N. Kanara, Karwar. 72. *P. ceylanica,* Feld. Ceylon. 73. *P. hippia,* Fabr. Rangoon. 74. *P. naraka,* Moore. Andaman Islands. 75. *P. naraka.* Scale from near apex of hind-wing. 76. *P. naraka?* Scale from border of hind-wing. 77. *P. boebera,* Eschsch. Philippine Islands. Scale from apical border of hind-wing. 78. *P. valeria,* Cram. Java. Wallace specimen. 79. *P. lutescens,* Butl. Borneo. 80. *P. phocoea,* Feld. Philippine Islands. 81. *P. tritaea,* Feld. Celebes: Menado. Wallace specimen. 82. *P. argolis,* Feld. Batchian. Wallace specimen. 83. *P. jobaea,* Boisd. New Guinea: Dorey. Wallace specimen. 84. *P. avatar,* Moore. Sikkim. 85. *Nepheronia thalassina,* Boisd. Lagos. Scale from fold at end of cell in hind-wing. 86. *N. argia,* Fabr. f. *varia,* Trim. Natal: Karkloof. 87. *L. argia.* Winnebar. 88. *N. pharis,* Boisd. [W. Africa.] 89. *Leuceronia buqueti,* Boisd. B.E. Africa. 90. *Eronia cleodora,* Hübn. Kenya: Taita. 91. *E. leda,* Boisd. Natal: Durban.

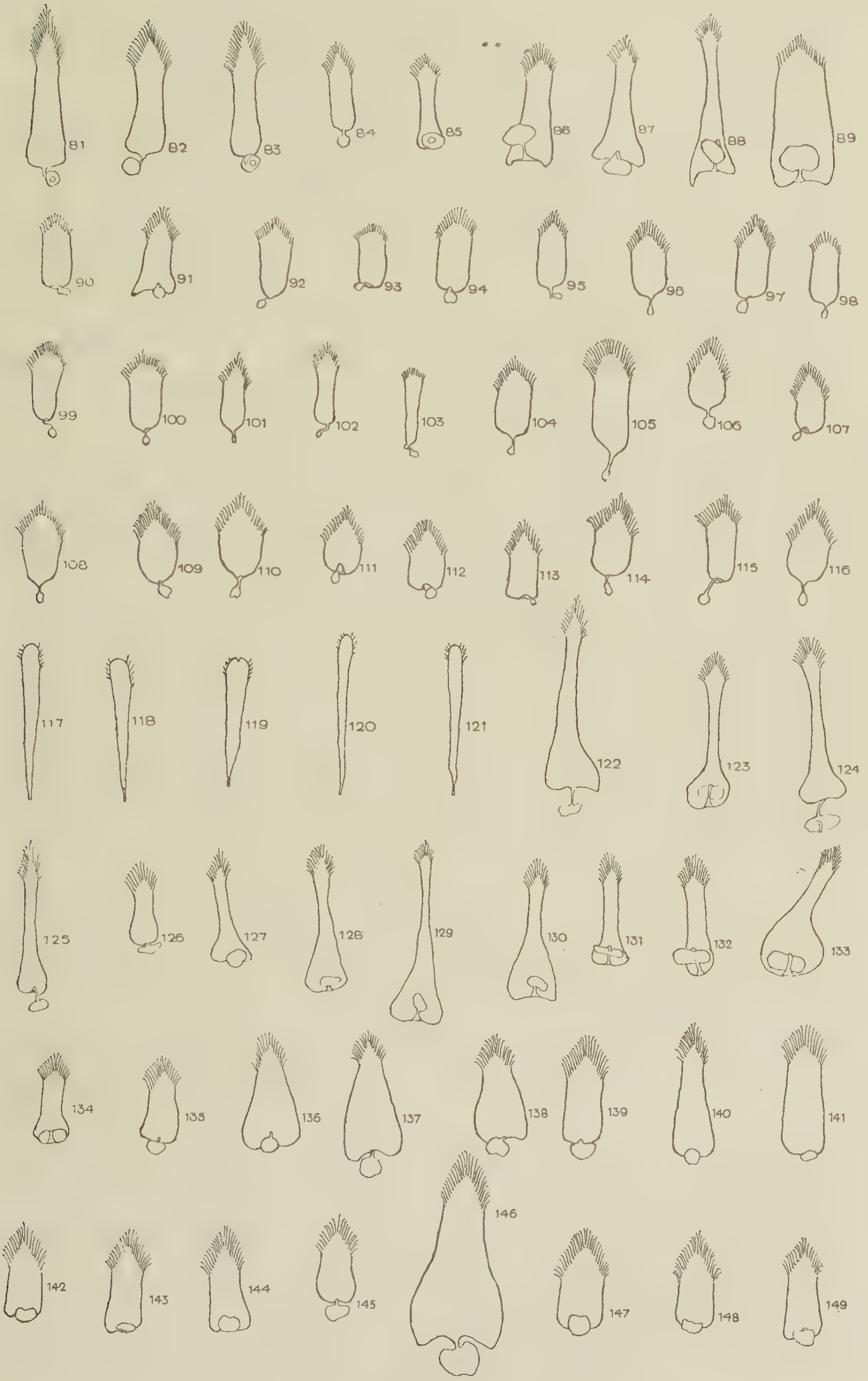
Figs. 92–105.—92. *Euchloe bieti,* Oberth. W. China: Szu-Chuan. 93. *E. genutia.* Fabr. [S.E. United States.] 94. *E. pima,* W. H. Edwards. Arizona; Texas. 95. *E. sara,* Luc. California. Scale from hind-wing. 96. *E. cardamines,* Linn, Pyrenees. 97. *E. ausonia,* Hübn. Switzerland: Valais. 98. *E. aegyptiaca,* Verity. Egypt: W. Desert Province. 99. *E. creusa,* Doubl. Vancouver Island. 100. *E. tagis,* Hübn. Spain: Granada. 101. *E. belemia,* Esp. Palestine. 102. *E. belemia,* Portugal. 103. *E. belia,* Linn. Algiers. 104. *Zegris olympia,* W. H. Edw. W. Manitoba. 105. *Eroessa chilensis,* Guér. S. Chile: Lota Baja.

Figs. 106–116.—106. *Hesperocharis hirlanda,* Stoll. Ecuador. 107. *H. nera,* Hew. Peru. 108. *H. nereina,* Hopff. S.E. Peru: Carabaya. 109. *H. pasion,* Reak. Mexico: Pacific Slope. 110. *H. marchali,* Guér. Bogota district. 111. *H. erota,* Luc. Brazil. Burchell specimen. 112. *H. anguitia,* Godt. Brazil. 113. *H. longstaffi,* Dixey. Venezuela: La Guayra. Scale from type. 114. *H. gayi,* Blanch. Chile: Valparaiso. 115. *Mathania agasicles,* Hew. Bolivia. Scale from type in British Museum. 116. *Hesperocharis* sp. Specimen in British Museum formerly included under *Mathania.* Elwes Collection.

Figs. 117–134.—117. *Daptonura isandra,* Boisd. Guatemala. 118. *D. leucanthe,* Feld. Bogota district. 119. *D. polyhymnia,* Feld. Colombia. 120. *D. lycimnia,* Cram. Trinidad. 121. *D. lycimnia,* Colombia. 122. *Pinacopteryx cebron,* Ward. Lagos. 123. *P. lindneri,* Dewitz. Angola. 124. *P. linderi,* W. Africa. 125. *P. orbona,* Hübn. Gambia. 126. *P. vidua,* Butl. Kenya: Taita. ? Foreign scale. 127. *P. vidua.* Usual form of scale. 128. *P. pigea,* Boisd. Natal: Malvern. 129. *P. dixeyi,* Neave. Uganda: Toro. Scale from co-type. 130. *P. spilleri,* Stdgr. Kenya: Taveta. 131. *P. charina,* Boisd. Natal: Tugela River. 132. *P. simana,* Hopff. S.W. of Lake Nyasa. Wet season. 133. *P. liliana,* Gr. Smith. Mombasa. 134. *P. venata,* Butl. White Nile: Gondokoro. Scale from ♂ type.

Figs. 135–161.—135. *Belenois helcida,* Boisd. Madagascar. 136. *B. hedyle,* Cram. Ashanti. 137. *B. ianthe,* Doubl. Sierra Leone. 138. *B. solilucis,* Butl. Uganda: Toro. 139. *B. thysa,* Hopff. Nyasaland. 140. *B. calypso,* Drury. Old Calabar. 141. *B. dentigera,* Butl. Nyasaland. 142. *B. theuszi,* Dewitz. S.W. Congo. 143. *B. theora,* Doubl. Ashanti. 144. *B. picta,* Neave. N.E. Rhodesia. Scale from co-type. 145. *B. peeli,* Dixey. Somaliland. Scale from co-type. 146. *B. antsianaka,* Ward. Madagascar. 147. *B. anomala,* Butl. Sokotra. Scale from specimen in British Museum. 148. *B. voeltzkowi,* Karsch. Madagascar. 149. *B. lata,* Neave. Congo: Lualaba District. Scale from co-type. 150. *B. zochalia,* Boisd. Cape Province. 151. *B. victoria,* Dixey, Toro. 152. *B. subeida,* Feld. Kenya: S. Kavirondo. 153. *B. gidica,* Godt. Natal: Durban. 154. *B. severina,* Cram. Accra. 155. *B. mesentina,* Cram. Zambesi. 156. *B. java,* Sparrm. Timor. Wallace specimen. 157. *B. teutonia,* Fabr. Queensland. 158. *B. peristhene,* Fabr. Samoa. 159. *B. clarissa,* Boisd. Fiji. 160. *B. margaritacea,* E. M. Sharpe. Kenya: Dabida Hills. 161. *B. raffrayi,* Oberth. Kenya: Tiriki Hills.

Figs. 162–182.—162. *Leuciacria acuta,* Roths. & Jord. N.W. Papua: Arfak Mountains. 163. *Delias nysa,* Fabr. Australia. 164. *D. momea,* Boisd. ? Java. 165. *D. ladas,* Gr. Smith. British Central New Guinea. 166. *D. thompsoni,* Joicey & Talbot. Dutch Papua. Scale from co-type. 167. *D. caroli,* Kenr. f. *wandammeneae,* Joicey & Talbot. Dutch Papua. Scale from co-type. 168. *D. dohertyi,* Oberth. f. *knowlei,*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TEXT-FIGS. 81–149.

Joicey & Talbot. N. Papua; Schouten Is.: Biak. Scale from co-type. 169. *D. ornytion*, Godm. & Salv. British New Guinea. 170. *D. nigrina*, Fabr. Brisbane. 171. *D. harpalyce*, Donov. Australia. 172. *D. aganippe*, Donov. Adelaide. 173. *D. talboti*, Joicey & Noakes. Schouten Is.: Biak. Scale from co-type. 174. *D. nigidius*, Misk. N. Queensland: Cairns. 175. *D. callistrate*, Gr. Smith. D'Entrecasteaux Archip.: Fergusson I. 176. *D. multicolor*, Joicey & Noakes. Scale from co-type. 177. *D. xelianthe*, Gr. Smith. ? E. Papua. 178. *D. gabia*, Boisd. New Guinea. 179. *D. maudei*, Joicey & Noakes. Schouten Is.: Biak. Scale from co-type. 180. *D. georgiana*, Gr. Smith. New Britain. 181. *D. dorimene*, Cram. Ceram. 182. *D. biaka*, Joicey & Noakes. Schouten Is.: Biak. Scale from co-type.

Figs. 183–200.—183. *Delias isse*, Cram. Ceram or Amboyna. 184. *D. euphemia*, Gr. Smith. Schouten Is.: Biak. 185. *D. mysis*, Fabr. Port Darwin. 186. *D. lara*, Boisd. British Papua. 187. *D. kummeri*, Ribbe f. *ligata*, Roths. N.W. Papua. 188. *D. dixeyi*, Kenr. N.W. Papua. 189. *D. iltis*, Ribbe. British Papua. 190. *D. bakeri*, Kenr. N.W. Papua. 191. *D. weiskei*, Ribbe. British Papua. 192. *D. callima*, Roths. & Jord. British Papua. 193. *D. niepelti*, Ribbe. British Papua. 194. *D. meeki*, Roths. N.W. Papua. 195. *D. heroni heroni*, Kenr. N. Papua: Arfak. 196. *D. heroni albo-oculatus*, Joicey & Noakes. N. Papua: Arfak. Scale from co-type. 197. *D. castaneus*, Kenr. N.W. Papua: Arfak. 198. *D. albertisi*, Oberth. Arfak Mountains. 199. *D. pratti*, Kenr. Arfak Mountains. 200. *D. emilia*, Roths. Arfak Mountains.

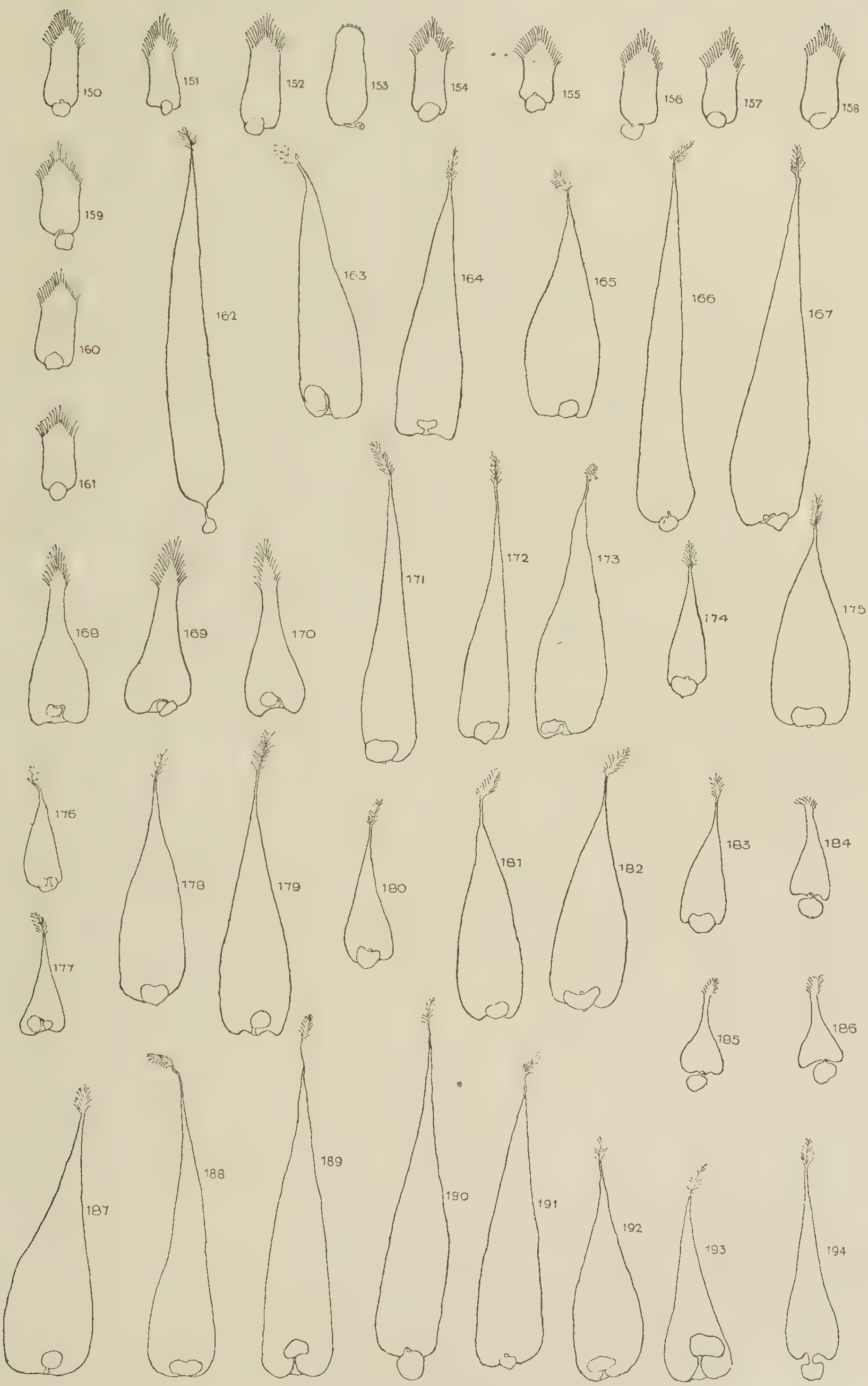
Figs. 201–220.—201. *Delias imitata*, Kenr. Arfak. 202. *D. cuningputi*, Ribbe. Arfak. 203. *D. aroae*, Ribbe. Arfak. 204. *D. fuliginosus*, Kenr. Arfak. 205. *D. microsticha flavipincta*, Jord. Arfak. Scale magnified about 110 diameters. 206. *D. microsticha*, Roths. British Papua: Owgarra. × 110. 207. *D. argenthona*, Fabr. Queensland, Moreton Bay. 208. *D. caeneus*, Linn. Amboyna. Wallace specimen. 209. *D. indistincta*, Fruhst. British North Borneo. 210. *D. eucharis*, Drury. India. 211. *D. stolli*, Butl. China. 212. *D. hierte*, Hübn. Rangoon. 213. *D. hyparete*, Linn. Java. 214. *D. niasana*, Kheil. N. Nias. 215. *D. descombesi*, Boisd. Yoonzaleen Valley. 216. *D. belisama*, Cram. Java. 217. *D. eumolpe*, Gr. Smith. British North Borneo. 218. *D. aruna*, Boisd. New Guinea: Humboldt Bay. 219. *D. inferna*, Butl. British New Guinea. 220. *D. diaphana*, Semper. Philippine Is.: Mindanao.

Figs. 221–232.—221. *Delias pyramus*, Wallce. Baliganji? 222. *D. ninus*, Wallce. Penang. 223. *D. aglaia*, Linn. Darjiling. 224. *D. parthenope*, Wallce. British North Borneo. 225. *D. parthenia*, Stdgr. British North Borneo. 226. *D. egialea*, Cram. Java. 227. *D. crithoe*, Boisd. Java. 228. *D. henningia*, Eschsch. Philippine Is.: Manilla. 229. *D. pandemia*, Wallce. Borneo. 230. *D. agostina*, Hew. Darjiling. 231. *D. cinerascens*, Von Mitis. Borneo: Sarawak. 232. *D. belladonna*, Fabr. Baliganji?

Figs. 233–245.—233. *Pereute charops*, Boisd. Panama. 234. *P. antodyca*, Boisd. Brazil: Rio. 235. *P. swainsoni*, Gray. Brazil. 236. *P. callinice*, Feld. Colombia. 237. *P. callinice*, West Central Peru. 238. *P. callinira*, Stdgr. Peru. 239. *P. callinira*, West Central Peru. 240. *P. leucodrosime*, Koll. [Colombia.] 241. *P. leucodrosime* f. *bellatrix*, Fruhst. West Central Peru. 242. *Leodonta tellane*, Hew. Bogota. 243. *L. chiriquensis*, Stdgr. Panama: Chiriqui. 244. *L. dysoni*, Doubl. [Colombia, Venezuela.] 245. *L. zenobia*, Feld. Bogota.

Figs. 246–270.—246. *Catasticta corcyra*, Feld. Ecuador. 247. *C. pieridoides*, Feld. Bogota. 248. *C. ctemene*, Hew. Ecuador. 249. *C. hegemon*, Godm. & Salv. Chiriqui. 250. *C. sisamnus*, Fabr. Panama: Bugaba. 251. *C. actinotis*, Butl. Costa Rica. 252. *C. pinava*, Doubl. Ecuador. 253. *C. semiramis*, Luc. Bogota. 254. *C. uricoecheae*, Feld. Colombia. 255. *C. anaitis*, Hew. Ecuador. 256. *C. nimbice*, Boisd. Mexico: Orizaba. 257. *C. ochracea*, Bates. Panama. 258. *C. bryson*, Godm. & Salv. Costa Rica. 259. *C. theresa*, Butl. & Druce. Panama: Chiriqui. 260. *C. flisa*, Herr.-Schäff. Panama. 261. *C. bithys*, Hübn. Brazil: Rio. 262. *C. manco*, Doubl. Colombia. 263. *C.* sp. (? *cora*, Luc. ? *zancle*, Feld.). Colombia: Bogota district. 264. *C. colla*, Doubl. S. Peru. 265. *C. philone*, Feld. Colombia: Bogota district. 266. *C. hebra*, Luc. Colombia: Bogota district. 267. *C. teutila*, Doubl. Mexico: Jalapa. 268. *C. tomiris*, Feld. Colombia: Antioquia. 269. *C. toca*, Doubl. W. Brazil. 270. *C. chrysolopha*, Koll. Bogota.

Figs. 271–288.—271. *Archonias approximata*, Butl. Guatemala. 272. *A. critias*, Feld. Colombia. 273. *A. tereas*, Godt. Rio. 274. *A. tereas*, form transitional to *A. nigripennis*. Brazil. 275. *A. bellona*, Cram. Ecuador. 276. *A. negrina*, Feld. Peru. 277. *A. rosacea*, Butl. N.W. Ecuador. 278. *A. nigripennis*, Butl. Ecuador.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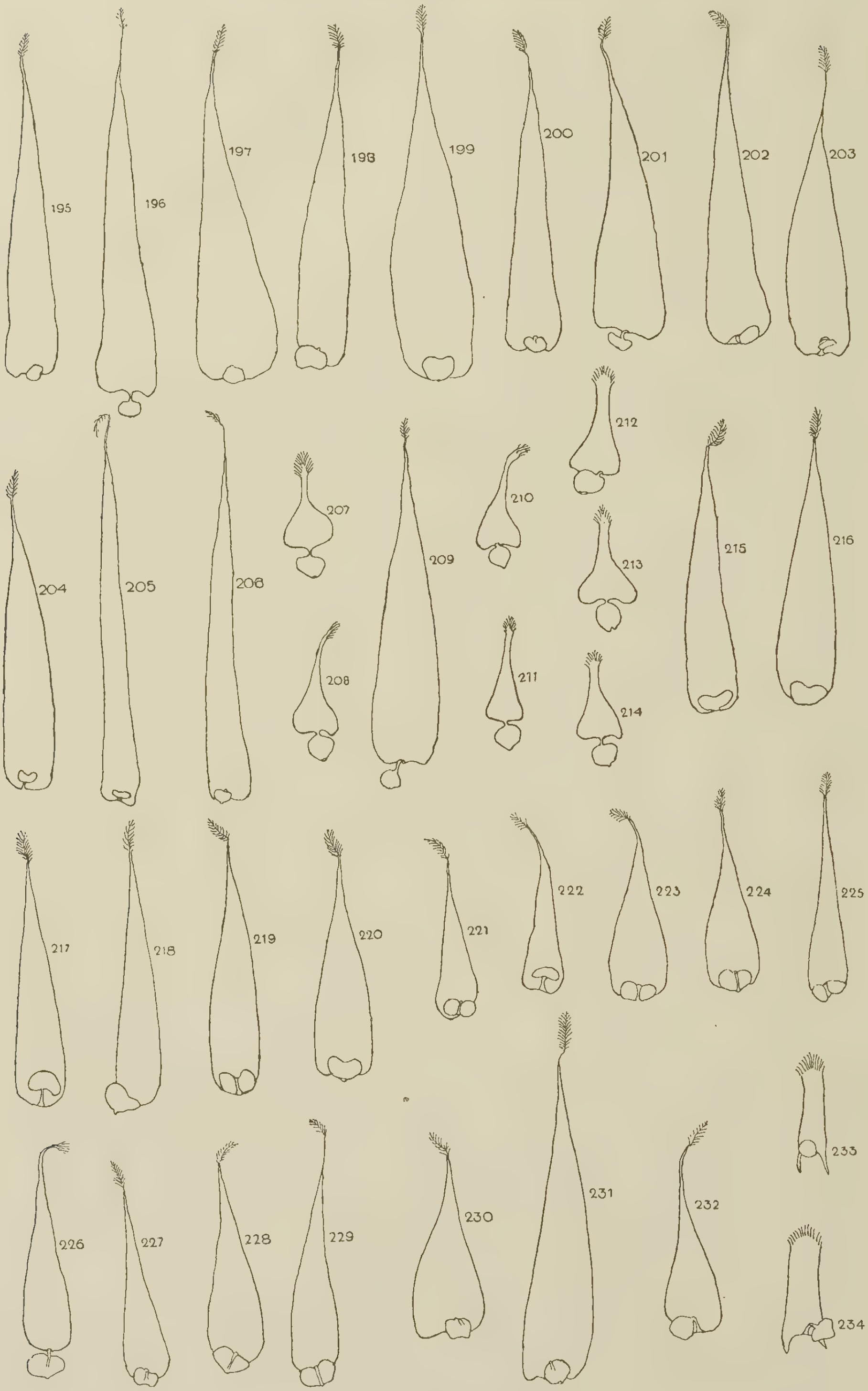
TEXT-FIGS. 150–194.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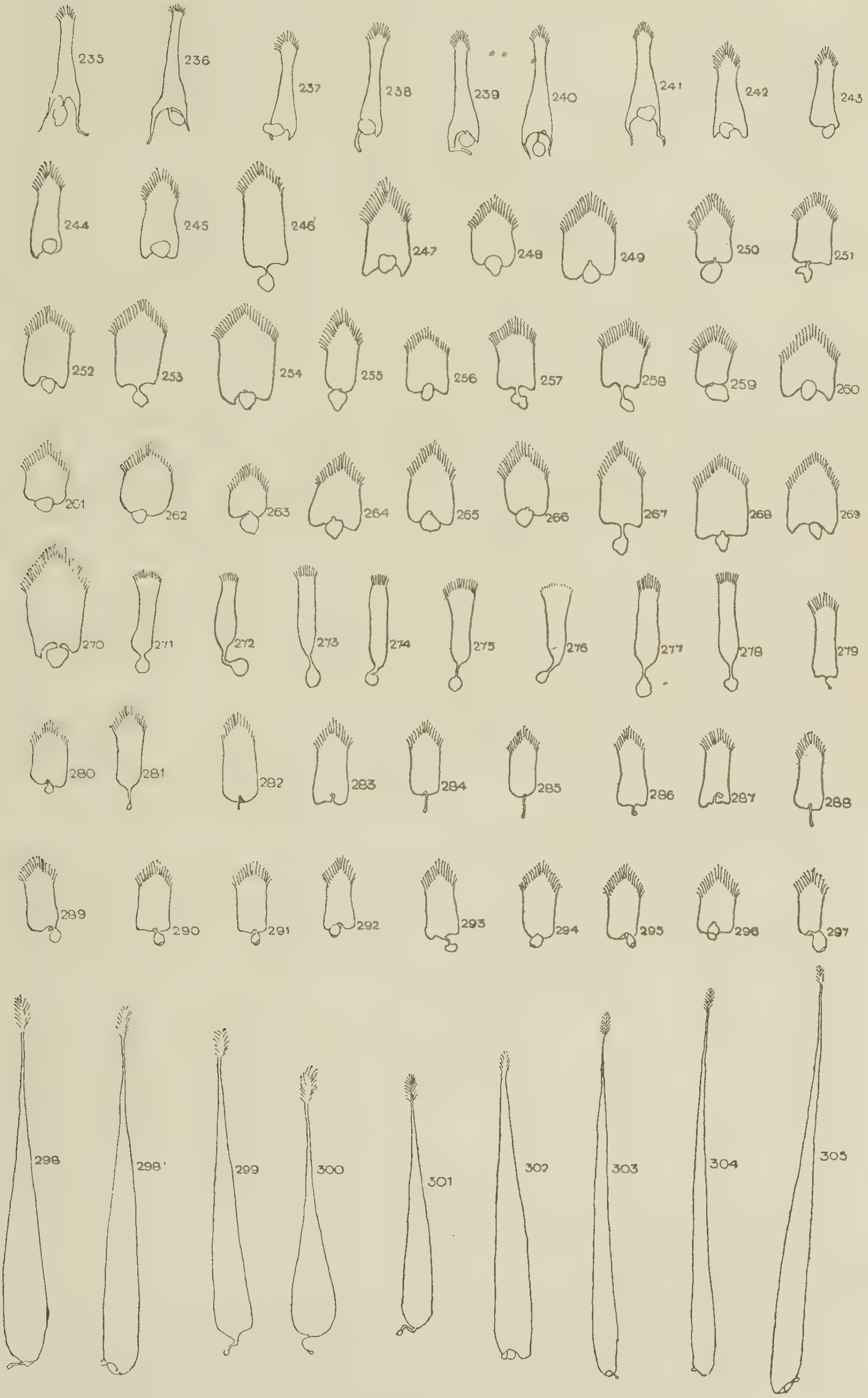
TEXT-FIGS. 195–234.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Text-figs. 235–305.

279. *Leptophobia aripa,* Boisd. [Central and S. America.] 280. *L. nephthis,* Hopff. W. Centr. Peru. 281. *L. erinna,* Hopff. Ecuador. 282. *L. eleone,* Doubl. & Hew. Bogota. 283. *L. tovaria,* Feld. Bogota. 284. *L. penthica,* Koll. Bogota. 285. *L. semicaesia,* Feld. [Colombia.] 286. *L. tenuicornis,* Butl. Panama. 287. *L. caesia,* Luc. Ecuador. 288. *L. cinerea,* Hew. Ecuador.

Figs. 289–297.—289. *Pieris viardi,* Boisd. Mexico: Atoyac. 290. *P. locusta,* Feld. Colombia. 291. *P. tithoreides,* Butl. Peru. 292. *P. mandela,* Feld. Venezuela. 293. *P. apicalis,* Boisd. [N.W. of S. America.] 294. *Itaballia calydonia,* Boisd. Guatemala. 295. *I. demophile,* Clerck. Amazon. 296. *I. marana,* Doubl. Ecuador. 297. *I. pylotis,* Godt. [Brazil.]

Figs. 298–305.—298. *Pieris phaloe,* Godt. Venezuela. 298′. *P. phaloe.* ? Venezuela. 299. *P. ausia,* Boisd. [Brazil.] 300. *P. diana,* Feld. Colombia. 301. *P. sevata,* Feld. Venezuela. 302. *P. buniae,* Hübn. Brazil. 303. *P. janeta,* Dixey. Venezuela. Magnified about 110 diameters. 304. *P. howarthi,* Dixey. Lower California. × 110. 305. *P. josepha,* Godm. & Salv. Tomellin. × 110.

Figs. 306–310.—306. *P. phileta,* Fabr. Brazil: Rio. 307. *Perrhybris pyrrha,* Fabr. [Brazil.] 308. *P. malenka,* Hew. [Venezuela.] 309. *P. lorena,* Hew. Amazon. 310. *P. lypera,* Koll. Brazil.

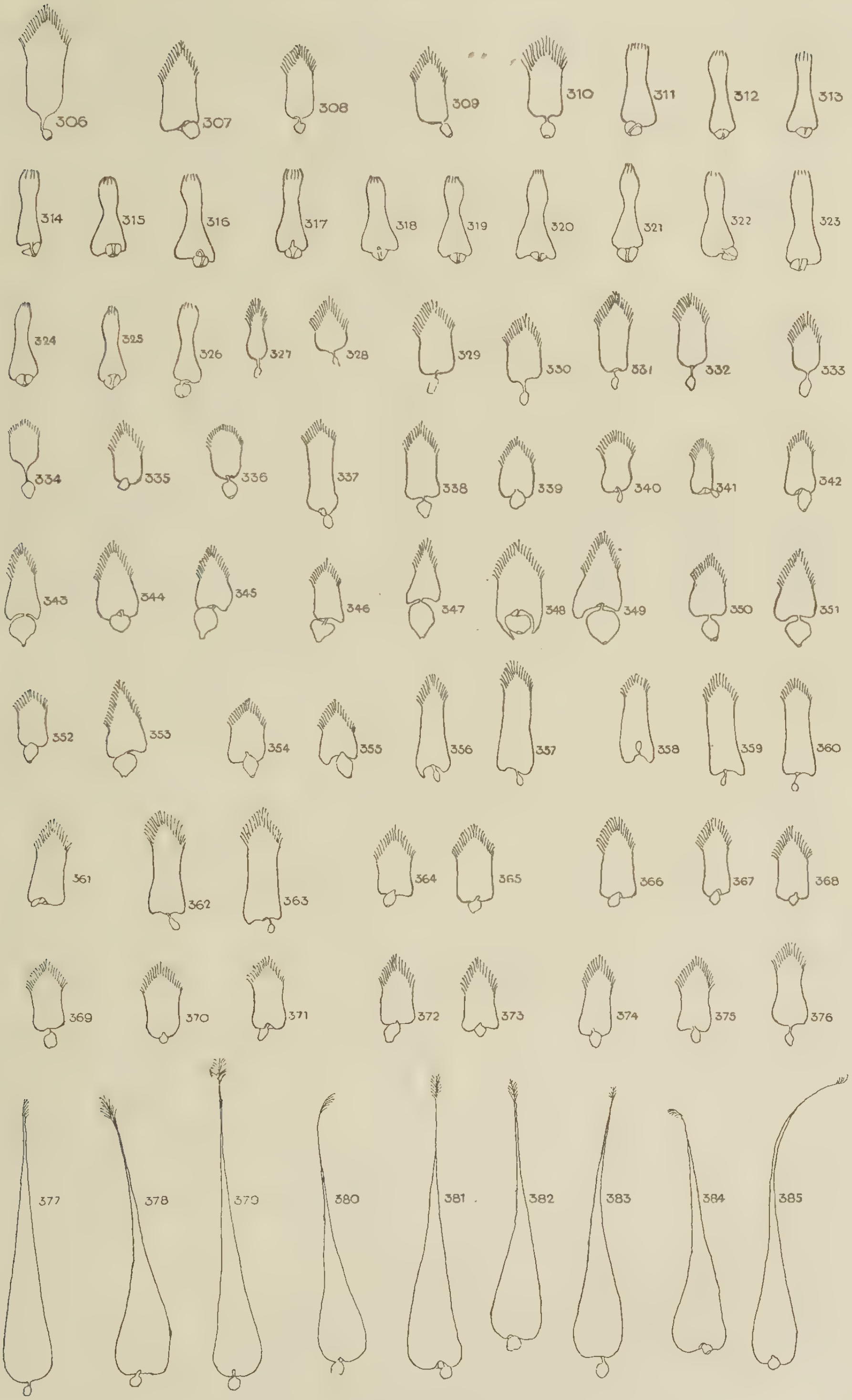
Figs. 311–326.—311. *Mylothris trimenia,* Butl. Cape Province: East London. 312. *M. narcissus,* Butl. Kenya: Sagalla Mts. 313. *M. jacksoni,* E. M. Sharpe. Kenya: Kikuyu. 314. *M. neumanni,* E. M. Sharpe. Kenya: Kikuyu. 315. *M. poppea,* Cram. V. Nyanza. 316. *M. spica,* Mösch. Old Calabar. 317. *M. rubricosta,* Mab. Kenya: Machakos. 318. *M. dimidiata,* Auriv. Sierra Leone. 319. *M. sulphurea,* Auriv. Lagos. 320. *M. yulei,* Butl. Kenya. 321. *M. phileris,* Boisd. [Madagascar.] 322. *M. bernice,* Hew. Gaboon. 323. *M. rüppelli,* Koch. Kenya. 324. *M. ngaziya,* Oberth. Grand Comoro Is. 325. *M. chloris,* Fabr. Cape Palmas. 326. *M. agathina,* Cram. Nyasaland.

Figs. 327–341.—327. *Nychitona xiphia,* Fabr. Singapore. 328. *N. dione,* Wallce. Celebes: Makassar. Wallace's co-type. 329. *Appias drusilla,* Cram. Guatemala. 330. *A. epaphia,* Cram. W. Africa. 331. *A. lasti,* Gr. Smith. Zanzibar. 332. *A. sylvia,* Fabr. Ashanti. 333. *A. sabina,* Feld. Nairobi. 334. *A. phaola,* Doubl. Cape Coast Castle. 335. *A. confusa,* Butl. Madagascar. 336. *A. isokani,* Gr. Smith. Kenya: Malindi. 337. *A. aegis* Feld. [Philippines.] 338. *A. libythea,* Fabr. Nilgiris. 339. *A. zelmira,* Cram. Upper Burma. 340. *Saletara liberia,* Cram. New Guinea: Andai. 341. *S. panda,* Godt. British North Borneo.

Figs. 342–355.—342. *Catophaga celestina,* Boisd. New Guinea: Port Moresby. Scale from fore-wing. 343. *C. celestina.* Scale from pale area of hind-wing. 344. *C. clementina,* Feld. Tenimber. Scale from fore-wing. 345. *C. clementina.* Scale from pale area of hind-wing. 346. *C. melania,* Fabr. Queensland: Cairns. Scale from fore-wing. 347. *C. melania.* Scale from pale patch of hind-wing. 348. *C. placidia,* Stoll. Amboyna. Wallace specimen. Scale from fore-wing. 349. *C. placidia.* Scale from dark patch near base of hind-wing. 350. *C. zarinda,* Boisd. Celebes: Menado. Scale from fore-wing. 351. *C. zarinda.* Scale from hind-wing. 352. *C. nero,* Fabr. Burma. Scale from fore-wing. 353. *C. nero.* Scale from hind-wing. 354. *C. domitia,* Fabr. Philippine Is.: Mindanao. Scale from fore-wing. 355. *C. domitia.* Scale from hind-wing.

Figs. 356–376.—356. *Appias lyncida,* Cram. Manipur. Scale from fore-wing. 357. *A. lyncida.* Scale from hind-wing. 358. *Catophaga nephele,* Hew. [Philippine Is.: Celebes.] Scale from fore-wing. 359. *C. nephele.* Scale from hind-wing. 360. *C. ithome,* Feld. E. Celebes. Scale from fore-wing. 361. *Hyposcritia cardena,* Hew. S. Sumatra. Scale from fore-wing. 362. *Appias hombroni,* Luc. Celebes: Menado. Scale from fore-wing. 363. *A. hombroni.* Scale from hind-wing. 364. *Hyposcritia lalage,* Doubl. Darjiling. Wet season. 365. *H. lalage.* E. Manipur. Dry season. 366. *H. lagela,* Moore. S. Perak. 367. *H. indra,* Moore. Manipur. 368. *H. plana,* Butl. Borneo. 369. *H. whiteheadi,* Gr. Smith. British North Borneo. 370. *H. pandione,* Hübn. [Java.] 371. *Catophaga paulina,* Cram. ? Baliganji. 372. *C. paulina.* Ceylon. 373. *C. jacquinoti,* Luc. Fiji. 374. *C. agave,* Feld. British North Borneo. 375. *C. ega,* Boisd. N. Australia. 376. *Udaiana cynis,* Hew. Borneo: Kinabalanghu.

Figs. 377–405.—377. *Huphina boisduvaliana,* Feld. Philippine Is. 378. *H. pitys,* Godt. Timor. 379. *H. wallaceana,* Feld. Waigiou Is. Wallace's specimen. 380. *H. quadricolor,* Godm. & Salv. New Britain. Scale from co-type. 381. *H. agnata,* Gr. Smith. Aola: Guadalcanar. 382. *H. periclea,* Feld. New Hebrides: Mallicolo Is. 383. *H. scyllara,* McLeay. Queensland: Moreton Bay. 384. *H. latilimbata,* Butl.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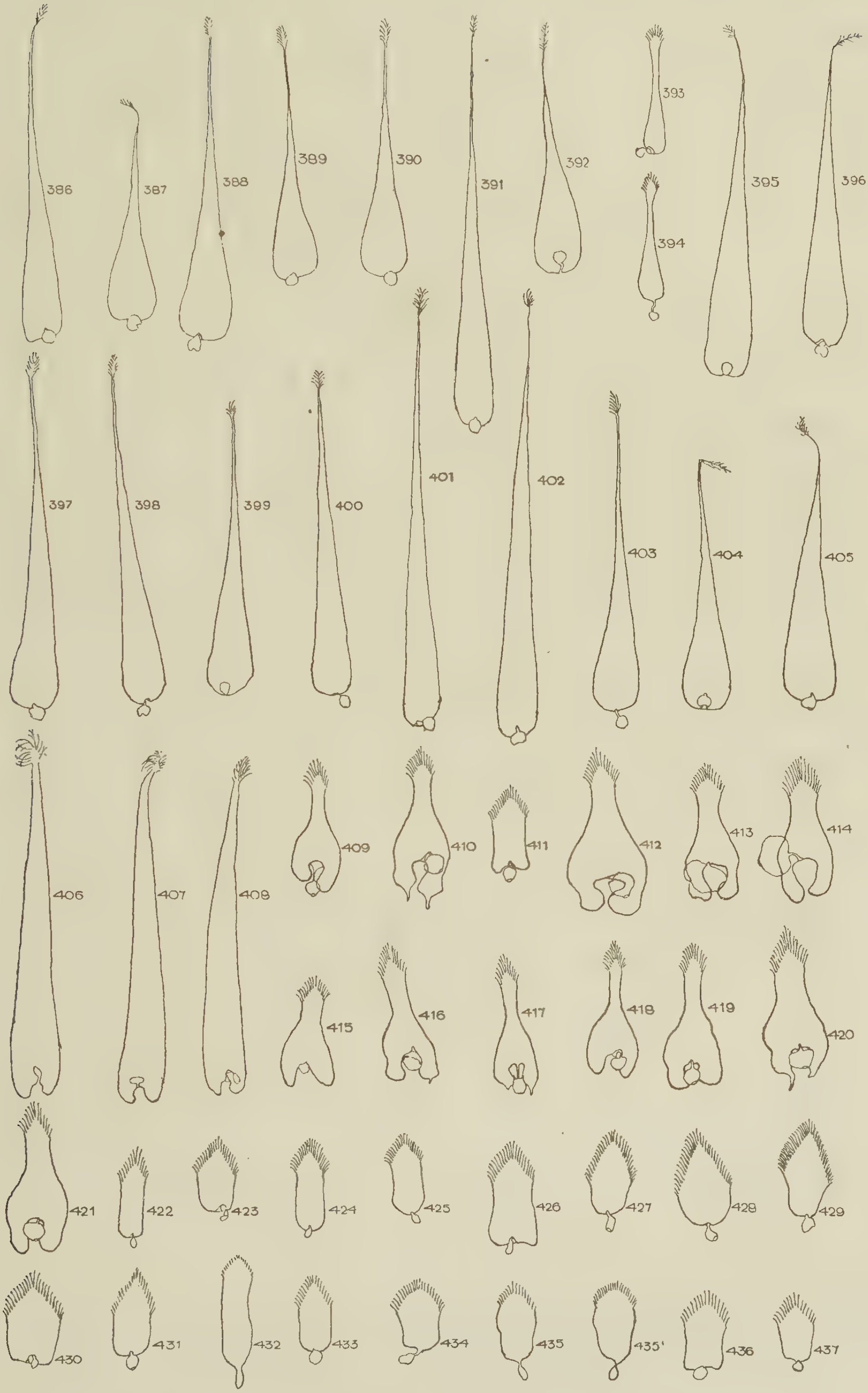
TEXT-FIGS. 306–385.

British Papua. 385. *H. perimale,* Donov. New Caledonia. 386. *H. acrisa,* Boisd. Loyalty Is. 387. *H. remba,* Moore. N. Kanara: Karwar. 388. *H. andamana,* Swinh. Andaman Is. 389. *H. nadina,* Luc. N. India. 390. *H. andersoni,* Dist. S. Perak. 391. *H. sumatrana,* Hag. W.C. Sumatra. 392. *H. fawcetti,* Butl. W.C. Sumatra. 393. *H. abnormis,* Wallce. New Guinea: Port Moresby. 394. *H. euryxanthe,* Honr. British Papua. 395. *H. nerissa,* Fabr. India: N.W. Provinces. 396. *H. lea,* Doubl. Rangoon. 397. *H. naomi,* Wallce. Flores Is. Wallace's cotype. 398. *H. amalia,* Voll. W.C. Sumatra. 399. *H. selma,* Weym. Nias Is. 400. *H. judith,* Fabr. Java. 401. *H. olga,* Eschsch. Philippine Is. 402. *H. aspasia,* Stoll. Amboyna. Wallace's specimen. 403. *H. eperia,* Boisd. Celebes: Makassar. Wallace's specimen. 404. *H. julia,* Doherty. Sumba Is. 405. *H. inopinata,* Butl. Fiji.

Figs. 406–421.—406. *Pieris cheiranthi,* Hübn. Tenerife. 407. *P. wollastoni,* Butl. Madeira. 408. *P. brassicae,* Linn. England: Essex. 409. *P. canidia,* Sparrm. India: Dalhousie. 410. *P. ajaka,* Moore. Burma. 411. *P. cisseis,* Leech. S. China. 412. *P. melete,* Ménetr. Japan. 413. *P. melete.* Tsu-Shima Is. 414. *P. melete.* Tsu-Shima Is. 415. *P. extrema,* Oberth. W. China. 416. *P. davidis,* Oberth. W. China. 417. *P. davidina,* Oberth. W. China. 418. *P. rapae,* Linn. France: Cannes. 419. *P. crucivora,* Boisd. Tsu-Shima Is. 420. *P. oleracea,* Harris. Vancouver. 421. *P. napi,* Linn. England: New Forest. August brood.

Figs. 422–431.—422. *Pontia daplidice,* Linn. Tenerife. 423. *P. chloridice,* Hübn. [S.E. Europe—W. Mongolia.] 424. *P. hellica,* Linn. Natal: Frere. 425. *P. johnstoni,* Crowley. Kenya. 426. *Tatochila xanthodice,* Luc. S. Peru. 427. *T. macrodice,* Stdgr. Ecuador. 428. *T. macrodice,* Peru. 429. *T. theodice,* Boisd. Valparaiso. 430. *T. autodice,* Hübn. Brazil. 431. *T. microdice,* Blanch. Patagonia: Andes.

Figs. 432–437.—432. *Neophasia menapia,* Feld. Vancouver Is. 433. *Aporia crataegi,* Linn. Locality not known. 434. *A. soracta,* Moore. India. 435, 435′. *A. procris,* Leech. Tse-Kou. Two scales from the same British Museum specimen. 436. *A. nabellica,* Boisd. 437. *A. llamo,* Oberth. Yunnan: Tse-Kai.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Text-figs. 386–437.

AFRICAN BEETLES OF THE FAMILY CARABIDAE

By A. W. J. Pomeroy.

[Read 2nd December, 1931.]

With Plates I–III and Forty-three Text-figures.

When embarking upon a systematic study of a group of insects, it is impossible to determine beforehand the amount of research likely to be required to produce a reliable interpretation of the problem. A classification may only afford a means by which individuals can be placed in apparent order for the sake of readily naming material, but it should have the basis of conforming as closely as possible to the true phylogeny of the group. This paper deals with the endeavour to find some structures having those characteristics, which show sufficient constancy within well-defined limits, to separate definitely groups of individuals and as far as possible species.

It was realised that in the time available, a monograph of even the African representatives of a Tribe such as the Chlaeniini was impossible, as, unless the types are examined, there can be no certainty as to the correctness of the nomenclature. Since the types are scattered in various museums and large private collections, at least two years must elapse before such a monograph could be completed.

The following preliminary scheme of work was therefore undertaken :—

(*a*) To make as accurate a catalogue as possible of the known African Carabidae ; (*b*) to concentrate on one tribe, the Chlaeniini, and to find some definite characteristics in the structure, which would serve as a basis of classification for the whole of the tribe ; (*c*) to deviate as little as possible from the main object in view by any non-essential study with regard to points of nomenclature or homology of the structures ; (*d*) to perfect laboratory methods of dissections and illustration for a larger work.

For reference this paper is divided into the following sections :—

(1) The importance of the female external genital characters in the family Carabidae.

(2) The value of the female genital armature, as systematic characters in dividing the Tribe Chlaeniini into sub-genera and in defining species.

(3) The microsculpture and puncturation of the elytra as a specific character in distinguishing closely allied species, when observed under a large magnification.

(4) Methods of laboratory technique employed.

Acknowledgements.

The writer wishes to express his thanks and appreciation for the help and advice given by the following entomologists :—To Professor E. B. Poulton, F.R.S., of the Hope Dept., Oxford, for his kindness in affording every facility for study ; to Mr. H. E. Andrewes and M. Charles Alluaud for a great deal of

material and many identifications; to Mr. G. J. Arrow of the British Museum for material and valuable suggestions; to Mr. L. A. Clinkard of the Forestry Dept., Oxford, for his aid in the photographic illustrations.

SECTION 1.

The Female External Genital Characters.

Considerable work has been done on the character of the male genitalia in certain groups of CARABIDAE, the most noteworthy being that of Jeannel in the genus *Trechus*. The homology and structure of the female genitalia has been admirably studied by Stein and Lacaze-Duthiers with regard to the interior anatomy; I have been unable, however, to find any reference in literature to the external and general structure of the female genitalia being used as a systematic character for classification.

After studying genitalia in other insects, one cannot help being impressed by the fact that in one or both of the sexes the structure usually shows remarkable and most intricate development. In the Diptera may be cited the family SIMULIIDAE—the male genitalia showed remarkable differentiation in structure, which settled beyond doubt the validity of certain species, which was further proved by the study of the respective immature stages (Pomeroy). The female genitalia in this case showed little or no difference of systematic value. Certain groups of CARABIDAE show good specific characters in the male genitalia, but for some reason the more striking characters of the female seem to have been overlooked. I suggest that this was probably due to the difficulties of preparation and dissection encountered by the systematists who have worked on the family.

In the tribe Chlaeniini I think that there can be no doubt as to the value of the female genital structure being greater than that of the male. It must be remembered, however, that though a fundamental and correct basis may be obtained from a critical study of a hidden structure, yet the external structures must be correlated as far as possible to enable other workers, who are not specialists in that group, to identify the material correctly. Once a basic classification is formed on the more constant internal structures of the genitalia, which cannot be examined without preparation, I think that an examination of the external structure according to the revised method of arrangement will provide external characters of real significance. By a combination of both methods I trust it will be possible to avoid the usage of "keys" on external characters alone, which often lead to such perplexing controversy.

The structural characters of the female genitalia used for systematic purposes in this paper have been found to be present in all specimens of CARABIDAE examined to date.

These structures are situated at the extreme end of the abdomen, to which I have given the following provisional nomenclature, the description commencing at the caudal end.

Ventrally, there are two clasper-like processes, adorned with spines, bristles, sometimes naked, which are termed the vaginal palpi (after Stein); dorsad of these lies a thick integument, which is the fold of the anal portion of the intestine, termed the anal plate. The vaginal palpi are supported by two chitinous structures, which I term the apical plates, and these are attached each to a broad plate, inwardly emarginate, which are called the basal plates. The outer apical margin of the latter is often extended into lobes or prominences to which the term "flanges" is given. The basal plates are in turn connected with the next segment of the abdomen by a chitinous membrane, bearing a spiracle on each side of the outer margin. The last two segments of the abdomen, the 8th and 9th, which consist of the structures figured, being only connected with the last visible ventral segment by a thin membrane, are capable of considerable extension and retraction. The intention of this description is to afford a tentative nomenclature of the parts figured and described, for purely systematic purposes, though every effort has been made to correlate these structures with the findings of previous authors. Fig. 1 shows an example of typical Carabid female genitalia with the nomenclature used in this paper.

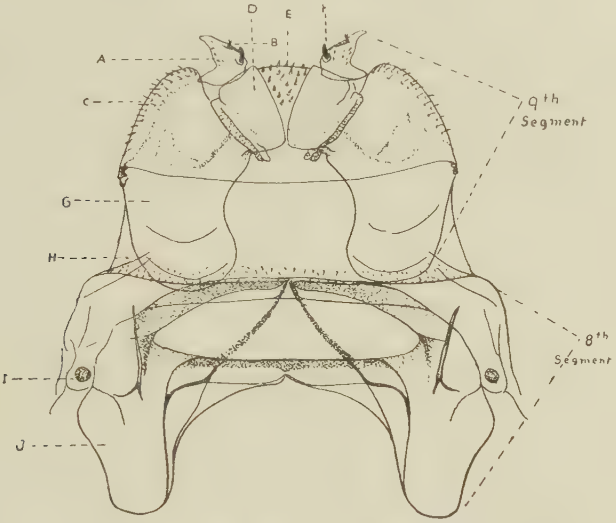


FIG. 1.—*Oodes helopioides*, Fab. Oodini.

A, Vaginal palpus; B, distal gland; C, flange; D, apical plate; E, anal plate; F, spine; G, basal plate; H, connecting membrane; I, spiracle; J, lobe of 8th segment.

The Characteristic Features of the Female Genital Armature of CARABIDAE, *with reference to the different Tribes.*

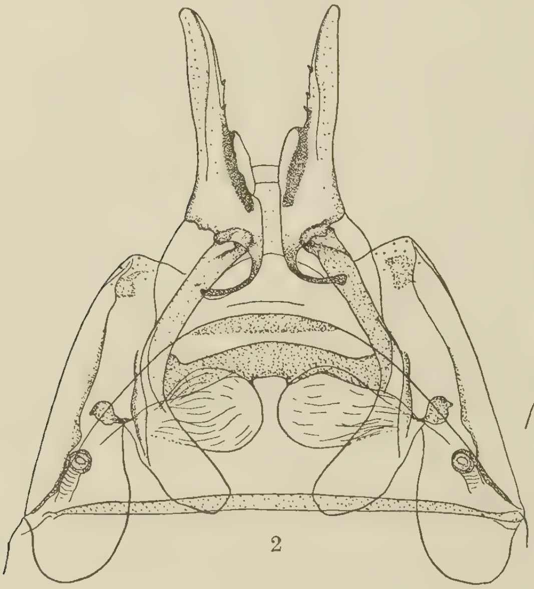
(1) OZAENINI: The Ozaenini and Scaritini appear to differ from all other tribes examined, in having the vaginal palpi fused with the apical plates. In the species figured, *Mystropomus subcostatus*, Chaud., the combined sclerites are long, slender, and bear on the inner margin a lobe, which seems to indicate the point of attachment of the vaginal palpi in other groups. Fig. 2.

(2) METRINI: Not examined.

(3) MIGADOPINI: Not examined.

(4) SCARITINI: The fused vaginal palpi and apical plates of *Scarites puncticollis*, Chaud., are short and hollowed out at the distal end, dorsally, showing a remarkable resemblance to a cat's ear. See Fig. 3.

SIAGONINI: *Siagona rufipes*, Fab.; the vaginal palpi are short, blunt and separated from the apical plates by a distinct suture. The apical plates bear a remarkable prolongation on the inner margin, giving the appearance of an added sclerite, while the basal plates consist of very chitinous attenuated arms. Fig. 4.



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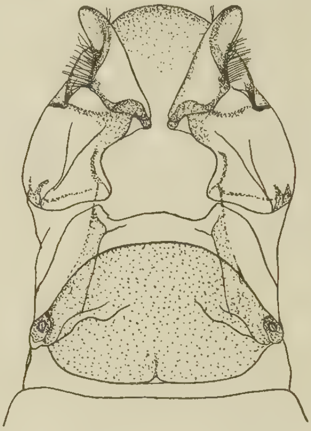

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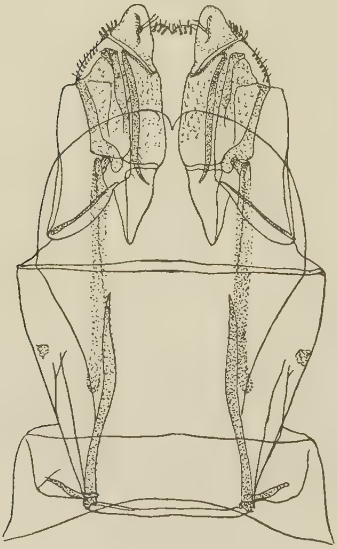
Fig. 2.—*Mystropomus subcostatus*, Chaud. Ozaenini.
Fig. 3.—*Scarites puncticollis*, Chaud. Scaritini.



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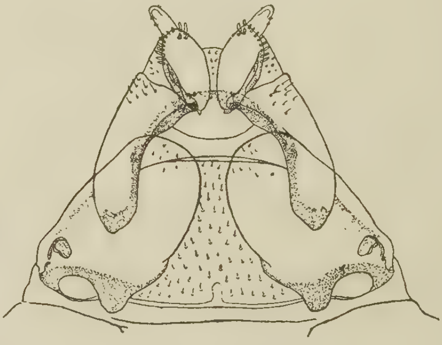

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Fig. 4.—*Siagona rufipes*, Fab. Siagonini.
Fig. 5.—*Elaphrus riparius*, L. Elaphrini.

Encelladini : Not examined.

Elaphrini : *Elaphrus riparius*, L.; the vaginal palpi are short, blunt, and the distal margin of the apical plates bear a row of very short stout spines. The basal plates are elongated. Fig. 5.

PROMECOGNATHINI : Not examined.

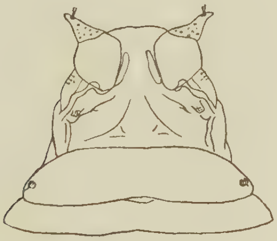
LORICERINI : *Loricera filicornis*, Fab.; the vaginal palpi are short, the apical plates broad, and covered with short bristles; the anal plate is covered with massed blunt spines either side; the basal plates are extended into bulbous lobes. Fig. 7.

OMOPHRONINI : *Omophron oberthuri*, Gestro.; the vaginal palpi are short, triangular in shape; the apical plates broad and rather bulbous. Fig. 6.

TRACHYPACHINI : Not examined.

OPISTHIINI : Not examined.

NEBRIINI : *Nebria jokischi*, Sturm; this tribe shows a remarkable development of the vaginal palpi, which are fused with the apical plates on the ventral surface, but there appears to be a definite suture across the more heavily chitinised portion of the dorsal surface. Mesad, at the base of the combined structure arise a pair of slender processes, which give the appearance of secondary vaginal palpi. The true vaginal palpi are very long, slender and pointed, adorned with spines on both margins, and, except for the presence of the suture previously mentioned, remarkably like those of the genus *Ozaena*. The basal plates are nearly as long as the palpi. Fig. 8.



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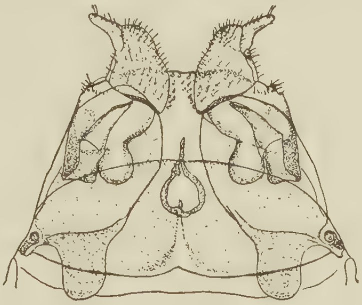

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FIG. 6.—*Omophron oberthuri*, Gestro. Omophronini.
FIG. 7.—*Loricera filicornis*, Fab. Loricerini.

NOTIOPHILINI : Not examined.

CARABINI : *Carabus violaceus*, L.; the vaginal palpi are short, distinct; the apical plates covered with short bristles; the basal plates are long, the inner margin oblique. Fig. 9.

HILETINI : Not examined.

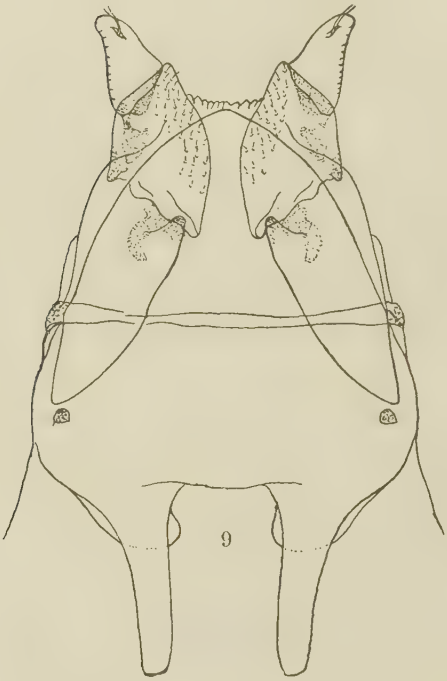
HEXAGONIINI : *Hexagonia praeusta*, Chaud.; the vaginal palpi are broad, sharply pointed at the distal end; they are partially covered with rows of very stout massed spines, in a manner resembling certain species of the genera *Chlaenius* and *Hololius*. The apical and basal plates are also somewhat similar, having a row of spines on the distal margin. Fig. 10.

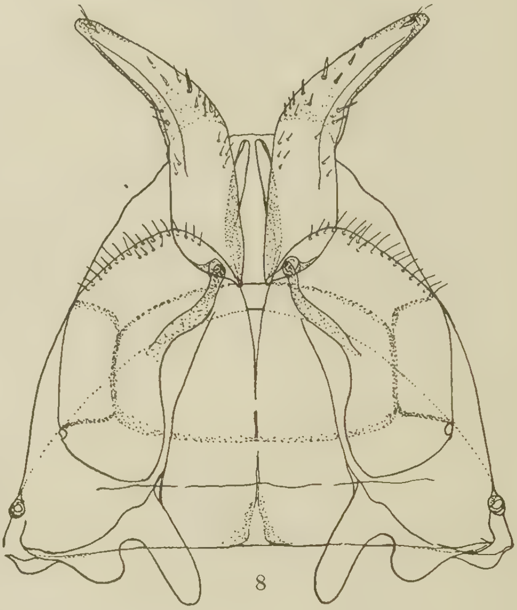
GRANIGERINI : *Graniger helferi*, Chaud.; the vaginal palpi are slender, pointed; the anal plate is composed of two ovate discs, adorned with blunt nodules; the apical plates are elongated and pointed on the inner margin. The general structure somewhat resembles the genus *Apotomus*. Fig. 11.

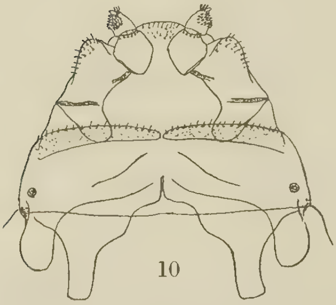
CUNEIPECTINI : Not examined.

PTEROSTICHINI : *Pterostichus madidus*, Fab.; the vaginal palpi are of medium length, curved outwardly and adorned with two spines on the outer margin, and a single spine on the inner, in a manner rather similar to *Chlaenius denticulatus*, Dejean. The basal plates are pronouncedly curved inwardly. Fig. 12.

MERIZODINI: Not examined.







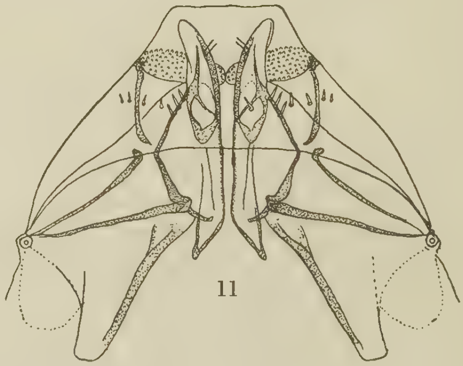


FIG. 8.—*Nebria jokischi*, Sturm. Nebriini.
FIG. 9.—*Carabus violaceus*, L. Carabini.
FIG. 10.—*Hexagonia praeusta*, Chaud. Hexagoniini.
FIG. 11.—*Graniger helferi*, Chaud. Granigerini.

BEMBIDIINI: *Bembidion clara*, Andrewes; the vaginal palpi are slender, pointed, adorned with two blunt spines on the outer margin; the apical plates are elongated, the basal plates are broad, each projecting into a very pronounced lobe at the base. Fig. 13.

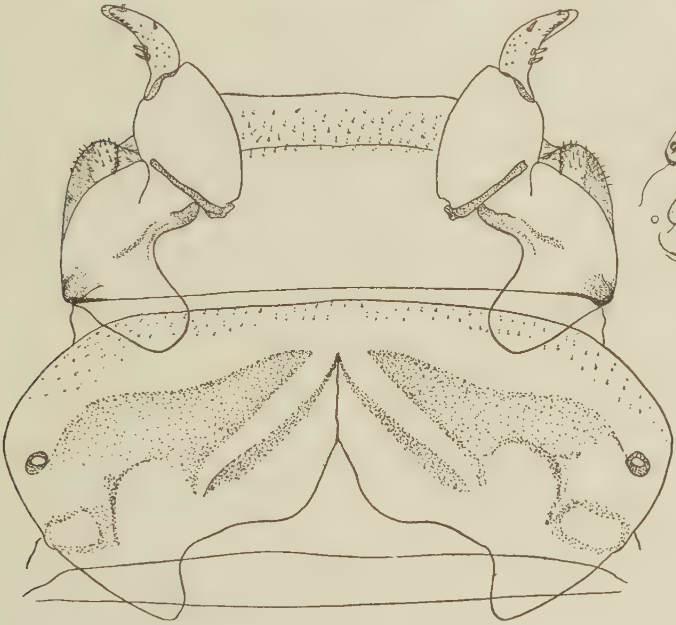
DISPHAERICINI: Not examined.

PELECHINI : Not examined.

BROSCINI : *Broscus cephalotes*, L. ; the vaginal palpi are very short, triangular shaped, unadorned with bristles or spines ; the apical plates are remarkably narrow, bearing a long row of stout spines on the outer distal margin and six stout spines diagonally at the distal end of the inner margin ; the basal plates are very elongated. Dorsad and mesad is situated a peculiar chitinous structure, triangular in form. Fig. 14.

AGONICINI : Not examined.

HARPALINI : *Harpalus aeneus*, Fab. ; the vaginal palpi are narrow, crescent-shaped and naked except for the two bristles arising from the gland on the inner margin ; the anal plate is covered with very stout spines ; the apical plates are narrow and adorned at the distal end and along the outer margin with stout spines ; the basal plates are broad. Fig. 15.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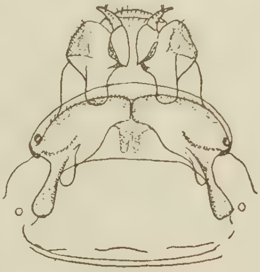
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FIG. 12.—*Pterostichus madidus*, Fab. Pterostichini.
FIG. 13.—*Bembidion clara*, Andrewes. Bembidiini.

TRECHINI : *Trechus discus*, Fab. ; the vaginal palpi are narrow and naked, except for the two bristles arising from the gland on the inner margin ; the apical plates are elongated, adorned with a very few short blunt spines at the distal end ; the basal plates are broad and large. Fig. 16.

ANCHOMENINI : *Anchomenus relucens*, Andrewes ; the vaginal palpi are very broad at base and pointed at the apex, adorned with three large blunt spines at the outer margin and a single spine on the inner ; the apical plates are very broad with a row of strong spines on the inner margin ; the basal plates are elongated into very pronounced lobes. Fig. 17.

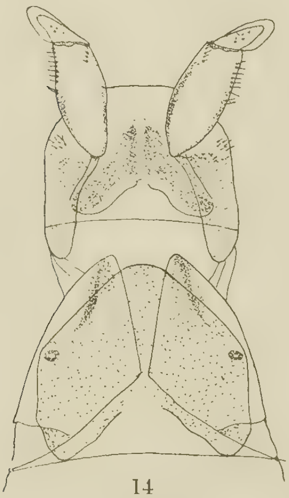
ODACANTHINI : *Odacantha melanura*, L. ; the vaginal palpi are very broad at base, pointed at apex and adorned with two blunt spines on the outer margin ; the flanges are very pronounced and the anal plate is covered with tubercles bearing each a single strong spine; the apical plates are of medium size, adorned with a row of very large irregular-shaped spines on the distal end; the basal plates are broad. Fig. 18.

Ctenodactylini: Not examined.

Cratocerini: Not examined.

Amorphomerini: Not examined.

Brachynini: *Brachynus crepitans*, Linn.; the vaginal palpi are of medium length, unadorned except for the presence of minute glandular orifices; the basal plates are broad and strongly emarginate inwardly; two remarkable tube-like processes are situated mesad and dorsad of the basal plates which connect with two large chitinous sacks. These processes are the organs which produce the volatile fluid used in defence when the insect is attacked. The fluid is expelled through the pair of tubes and explodes on contact with the air. Fig. 19.



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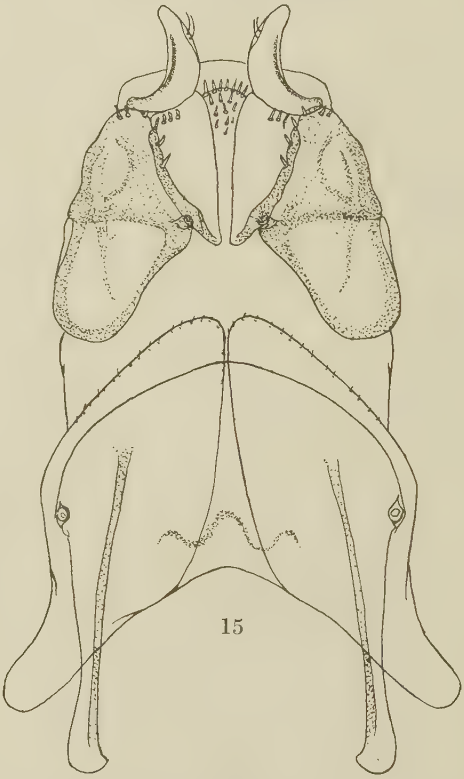

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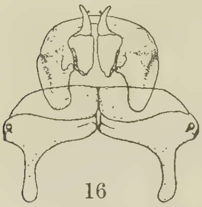

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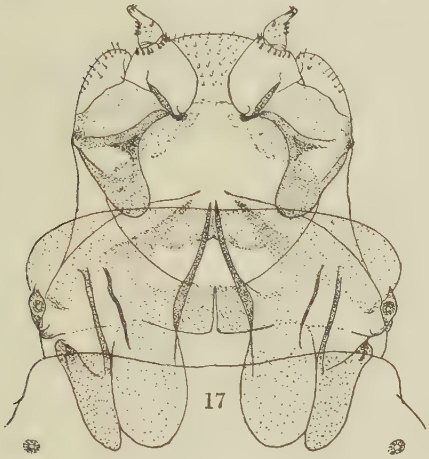
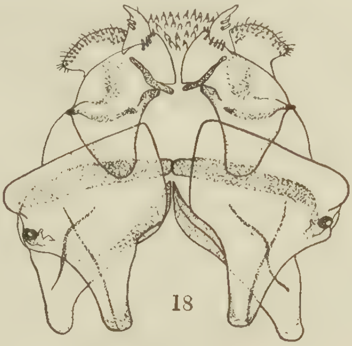
Fig. 14.—*Broscus cephalotes*, L. Broscini.
Fig. 15.—*Harpalus aeneus*, Fab. Harpalini.
Fig. 16.—*Trechus discus*, Fab. Trechini.

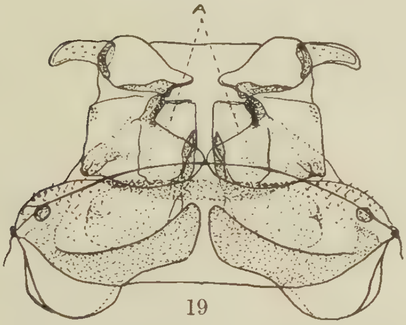
Apotomini: *Apotomus hirsutulus*, Bates; the vaginal palpi are narrow, the dorsal surface being hollowed out into a spoon-shaped cavity, naked except for a single bristle situated in the distal gland; the apical plates are elongated, bearing two very large spear-shaped spines on the distal portion of the outer margin and a row of spines extending diagonally across the dorsal surface; a pair of finger-shaped lobes are situated mesad and dorsad of the apical plates, bearing strong spines; the basal plates are very elongated and pointed. Fig. 20.

LICINIINI: *Licinus silphoides*, Fab.; the vaginal palpi are narrow, pointed and bear a single stout spine on the inner and outer margins; the apical plate is of medium size; the basal plates are projected into very pronounced lobes. The entire structure much resembles *Chlaenius obesus*, Fab. Fig. 21.

PANAGAEINI: Not figured. *Panagaeus crux major*, L.; the vaginal palpi are pointed and adorned with a very long spine on the inner and outer margin; the apical plates are approximately the same length as the vaginal palpi; the basal plate is very broad; apart from the shape of the basal plate, the entire structure is very like the preceding species.







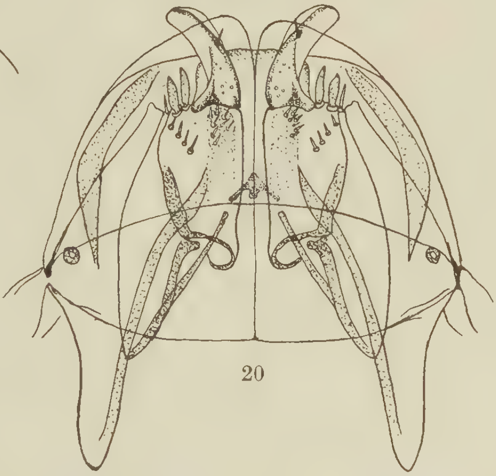


FIG. 17.—*Anchomenus zelucens*, Andrewes. Anchomenini.
FIG. 18.—*Odacantha melanura*, L. Odacanthini.
FIG. 19.—*Brachynus crepitans*, L. Brachynini. A, tubes of "bombing" apparatus.
FIG. 20.—*Apotomus hirsutulus*, Bates. Apotomini.

CHLAENIINI: This tribe is discussed and figured separately.

OODINI: *Oodes helopioides*, Fab.; the vaginal palpi are very broad, short, and adorned with a very strong blunt spine on the inner margin; the apical plates are of medium length; the basal plates are very broad. Fig. 1. See p. 79.

TETRAGONODERNII: Not examined.

AGRINI: Not examined.

LEBIINI: *Lebia chlorocephala*, Hoff.; the vaginal palpi are very remarkable, being reduced to flat rounded discs, unadorned except for minute "pits";

the apical plates are rounded, finger-like in shape; the basal plates are broad at base. Fig. 22.

PENTAGONICINI: Not examined.

HELLUONINI: *Helluo costatus*, Bon.; the vaginal palpi are slender, pointed and unadorned except for a minute pubescence; the apical plates are broad; the flanges are covered with prominent bristles; the basal plates are very curved on the inner margin, projecting horizontally into very pronounced lobes. Fig. 23.

PHYSOCROTAPHINI: Not examined.

ORTHOGONIINI: *Orthogonius* spp.; the vaginal palpi are very short and unadorned except for a pair of bristles arising from the distal gland; the apical plates are elongated; the basal plates are very pointed at the end. Fig. 24.

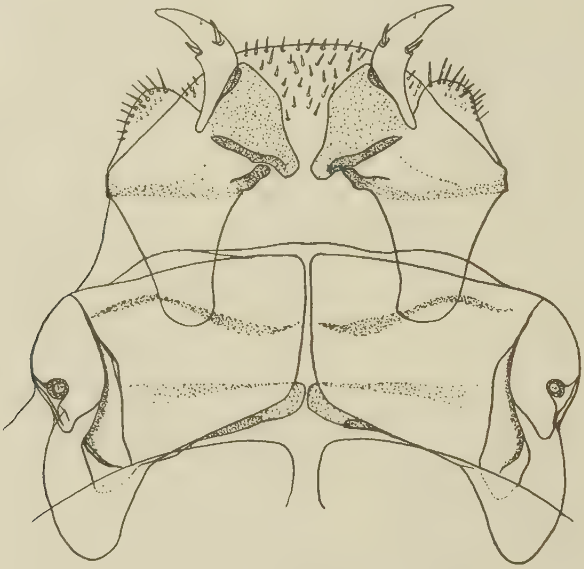


FIG. 21.—*Licinus silphoides*, Fab. Licinini.

ZUPHIINI: Not examined.

DRYPTINI: *Drypta dentata*, Rossi; the vaginal palpi are long, slender, and adorned with three spines on the outer margin and two on the inner margin toward the distal end; the apical plates are narrow, pointed; the flanges are very pronounced; the basal plates are crescent-shaped. Fig. 25.

MORMOLYCINI: Not examined.

GRAPHOPTERINI: Not examined.

ANTHIINI: *Anthia sex-guttata*, Fab.; the vaginal palpi are short, and covered with short bristles; the apical plates are rather bulbous and covered with short bristles on the apical half; there is a patch of long bristles situated on the apical portion of the inner margin; the basal plates are projected into long lobes. Fig. 26.

PSEUDOMORPHINI: Not examined.

A perusal of the species illustrated gives the general impression that further study of the various characters will provide a basis for more accurate grouping of the genera. Sloane's Table of Tribes has been adopted as being the most satisfactory classification in existence, but when such tribes as the Lebiini and Chlaeniini are considered in the light of new evidence, it is probable that some genera will be removed and either placed under other tribes or a new tribe be created. It may be possible to show that the structure of the eighth segment will be of systematic value, as in some cases the sclerites forming the segment are fused and in others they are divided. It is evident, however, that certain genera placed near the genus *Chlaenius* have structures which can be correlated with certain groups in that genus, at present combined under one general system.

However carefully genitalia may be described, it is impossible to convey the correct interpretation unless an accurate illustration is provided.

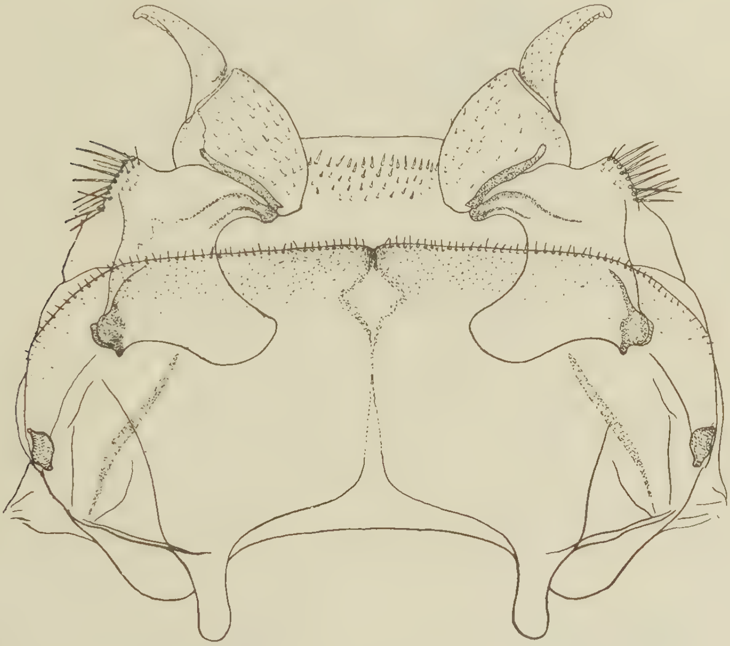


FIG. 23.—*Helluo costatus*, Bon. Helluonini.

SECTION 2.

The importance of the Female Genitalia in providing a means of separating the Tribe Chlaeniini into Groups and Species. See Table, p. 100.

A very large number of preparations have been made from named specimens in various collections. So far only the African representatives have been dealt with. It is impossible to be sure of the identifications until the types can be examined, but as far as possible those selected for illustration correspond with the descriptions and references in literature. The references are cited in chronological order, and all have been verified with the originals. It is also stated in the legend, whether the type has been examined or not. A representative species has been selected in each case as the type of that particular group.

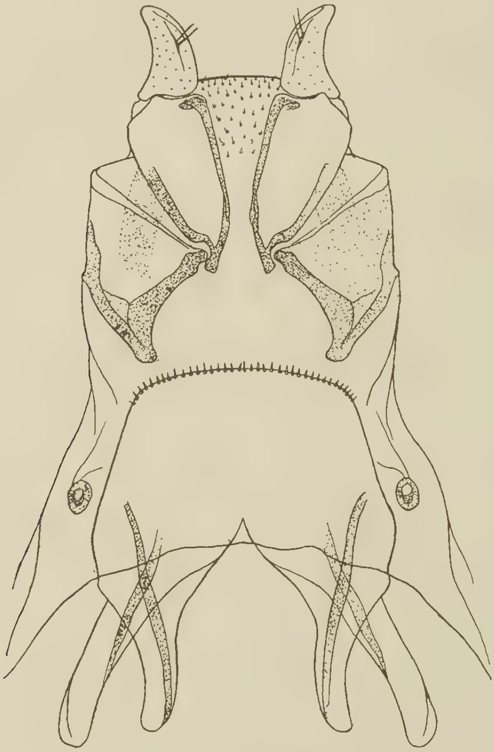
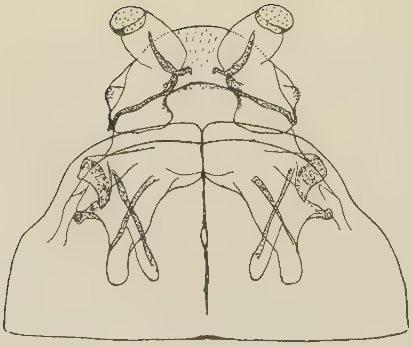


Fig. 24.—*Orthogonius* sp.



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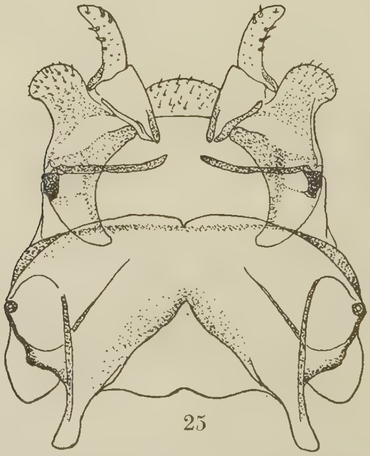

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Fig. 22.—*Lebia chlorocephala*, Hoff. Lebiini.
Fig. 25.—*Drypta dentata*, Rossi. Dryptini.

The first group discussed consists of the following species examined, of which *Chlaenius mirificus*, Pomeroy, has been selected as typical. The vaginal palpi of this group are pointed at the distal end and bear a single strong spine towards the base of the inner margin and a row of very stout spines along the outer margin. The number and the curved angle of this row of spines is the important distinguishing character.

Chlaenius mirificus, sp. n. (Pl. I, fig. 3.)

Colour : head and thorax deep metallic rose with bronze-green iridescence in some lights; elytra shining black. *Length :* 16·5 mm. *Head :* shining, finely punctured, front slightly rugose, but without any microscuplture; front margin of labrum straight, apical joint of maxillary palpi broad; antennae with the three proximal joints red-brown, remainder fuscous. *Thorax :* shining, very rugose, and sparely but deeply punctured. *Elytra :* deeply, but rather widely punctured, usually with four punctures transversely across the intervals, adorned with isodiametric microsculpture and covered with a golden pubescence; an irregular orange patch occurs, extending over the fourth to eighth intervals, situated well towards the caudal end of the elytra. *Legs :* shining red-brown; claws simple. *Female genitalia :* vaginal palpi the same length as the apical plate, a single long curved spine situated towards the base of the inner margin, the outer margin bears a row of strong spines usually eleven in number. The same number of spines is not always present on each of the vaginal palpi, but the curve of the outer margin from the apex to the base remains the same in all specimens examined. The following table shows the number of spines on the right and left vaginal palpi from ten specimens examined.

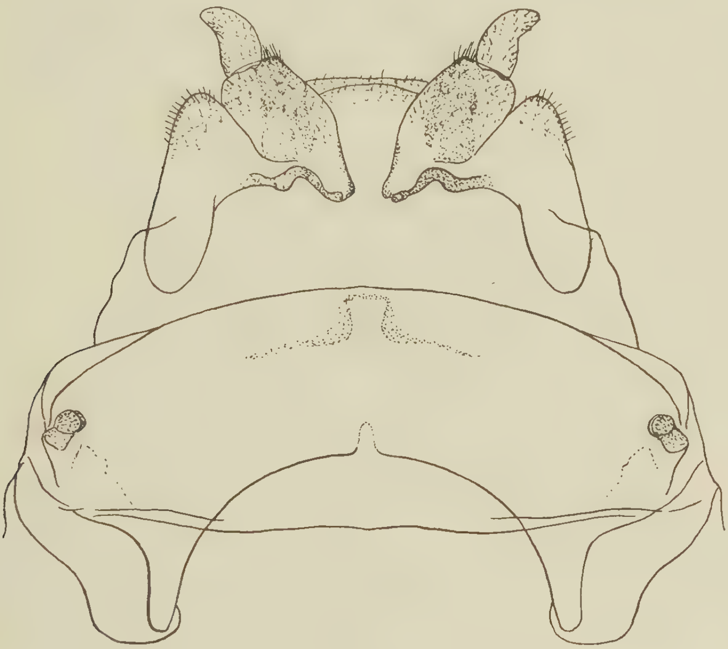


Fig. 26.—*Anthia sex-guttata*, Fab. Anthiini.

Right vaginal palpi. Number of spines.	Left vaginal palpi. Number of spines.	Proportionate number of specimens examined.
12	10	2
10	11	1
11	11	4
12	11	1
11	12	1
12	12	1

The shape of the curve is the characteristic feature. Fig. 27.

The holotype, female, bears ten spines on the right vaginal palpus and eleven on the left. The flanges of the basal plates bear a number of short bristles on the outer margin of the apex and a few long stout bristles along the margin. The basal plates are broad and strongly curved on the inner margin.

Habitat: Holotype female from Entebbe, UGANDA, East Africa, 3.iv.1913 (*C. C. Gowdey*); co-types from same locality taken by C. A. Wiggins, 1912.

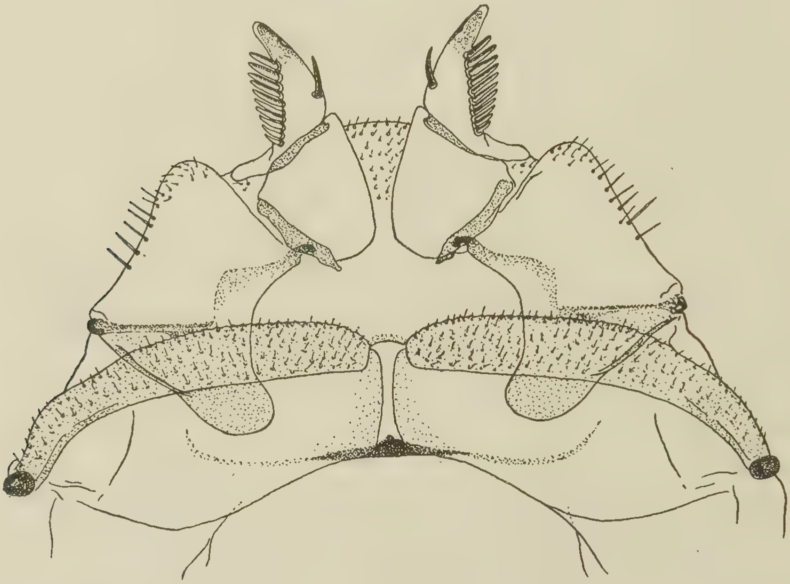


FIG. 27.—*Chlaenius mirificus*, Pomeroy.

The holotype ♀ has been placed in the British Museum. The species was described from fifty specimens.

This species is closely allied to *Chlaenius analis*, Olivier, and *C. antennatus*, Chaud., but differs from the latter in size, in the shape and sculpture of the thorax and the puncturation of the elytra.

Chlaenius poultoni, sp. n. (Pl. I, fig. 2.)

Colour: head and thorax bronze-green, sometimes copper-bronze in some lights; elytra shining black, suffused with bronze-green. *Length:* 13·5 mm. *Head:* shining, finely rugose, but without any microsculpture; cephalic margin of labrum straight; apical joint of maxillary palpi elongated; antennae with the first three proximal joints light red-brown, remainder fuscous. *Thorax:* deeply and thickly punctured, strongly curved inwardly towards the basal margin. *Elytra:* thickly punctured, with seven punctures transversely across the intervals, adorned with isodiametric microsculpture and normally covered with a light golden pubescence. An irregular dull orange patch occurs extending from near the margin of the third to eighth intervals, situated well towards the caudal end of the elytra. *Legs:* deep orange-brown, claws simple. *Female genitalia:* vaginal palpi almost the same length as the apical plate, a single long curved spine situated towards the base of the inner margin; the outer margin bears a row of strong stout spines, usually seven in number; the angle of the curve of the spines from apex to base is decidedly oblique. The following table gives the number of spines on the right and left palpi from twelve specimens examined.

Right vaginal palpus. Number of spines.	Left vaginal palpus. Number of spines.	Proportionate number of specimens.
7	6	2
8	6	1
7	7	5
7	8	2
8	8	2

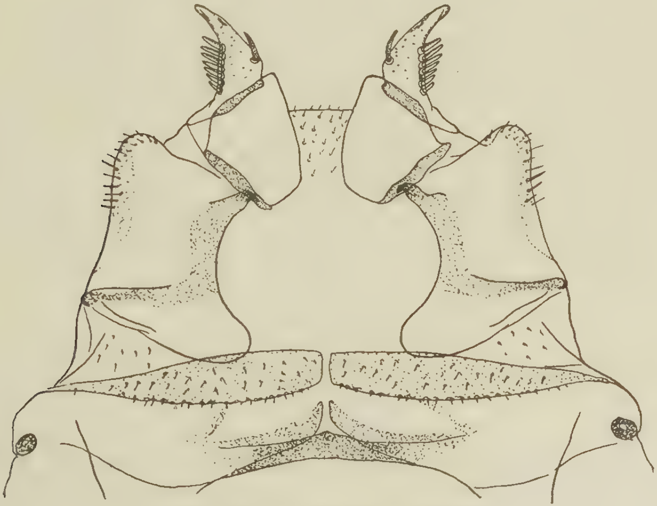


FIG. 28.—*C. poultoni*, Pomeroy.

The holotype female bears seven spines on each palpus. Fig. 28.

The flanges of the basal plates bear a few short bristles at apex and a few long bristles along the outer margin.

Habitat: Holotype from Entebbe, UGANDA, East Africa, ix.1912 (*C. A. Wiggins*); other localities are Kampala, UGANDA; Mabira Forest, UGANDA; Luangwa River, N.E. RHODESIA. Described from thirty specimens. The holotype ♀ has been placed in the British Museum.

This species is very closely allied to *Chlaenius analis*, Olivier, but differs absolutely in the puncturation of the elytra, being more thickly punctured than the above species and also in the female genitalia, the number of spines on the vaginal palpi being much fewer in number and the curve of the outer margin being very noticeably more oblique.

Chlaenius analisimilis, sp. n. (Pl. I, fig. 4.)

Colour: Head and thorax bronze-green sometimes copper-bronze in some lights; elytra shining black, suffused with bronze-green. Length: 14 mm. *Head:* shining, finely punctate rugose, but with no microsculpture; front margin of labrum straight; antennae with the first three proximal joints light red-brown, remainder black. *Thorax:* deeply and coarsely punctured; much broader than *C. poultoni*; the outer margin very slightly curved inwardly; much brighter bronze-green in colour than that of *C. analis*. *Elytra:* more thickly and finely punctate than *C. analis*, heavily adorned with isodiametric microsculpture and normally covered with a light golden pubescence. An irregular dull light orange patch extends from the margin of the third to the seventh intervals, situated well toward the caudal end of the elytra. *Female genitalia:* vaginal palpi the same length as the apical plate; a single long curved spine situated about two-thirds the distance from the apical end on the inner margin; the outer margin bears a row of strong stout spines; from ten to eleven in number, the spines diminish in size from the fourth from the apical end, and are much longer and more pointed than in *C. analis*. The angle of the outer margin appears to be much more oblique. The holotype female bears ten spines on the right and eleven on the left vaginal palpus. Fig. 29. The flanges of the basal plates bear a row of long bristles on the outer margin and a few shorter bristles at the apical end.

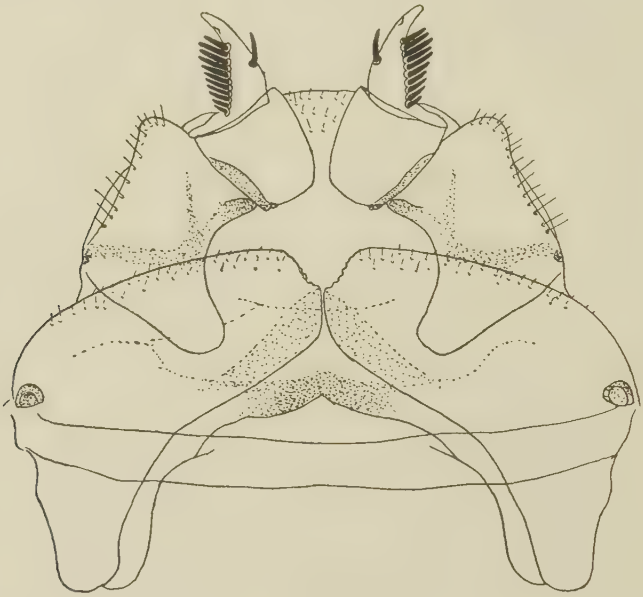


Fig. 29.—*C. analisimilis*, Pomeroy.

Habitat: Luingu, N.E. Rhodesia, 9.x.1908 (*Dr. S. A. Neave*). Described from four females. The males are similar in appearance. Type placed in the Hope Museum, Oxford.

This species is very close to *C. analis*, Oliv., but differs in the coloration, which is much brighter green, in the puncturation of the elytra, which is much finer, and differently arranged, also in the female genitalia which has been referred to above.

Chlaenius analis, Olivier, was described from Senegal, and *Chlaenius poultoni,* Pomeroy, may be said to be the East Coast representative. I place it between *C. boisduvali,* Dejean, and *C. analis,* Olivier.

Chlaenius analis, Olivier.

1795. Olivier, Ent. III, No. 35, p. 71; pl. 10, f. 115 (*Carabus analis*).
1831. Dejean, Spec. V, p. 623 (*Chlaenius caecus*).
1832. Klug, Symb. Phys. III, t. 24, f. 3 (*coecus*).
1856. Chaudoir, Bull. Soc. Nat. Mosc., **1856** (III) : 201 (*C. analis*).
1868. Gemminger und Harold, Cat. Col., p. 214 (*C. analis*).
1876. Chaudoir, Ann. Mus. Civ. Genova, **8** : 46 (*C. coecus*).
*1880. Mars, L'Abeille, **19** : 183.
*1908. Heyne und Taschenberg, Exot. Kafer, p. 22.
1931. Csiki, Col. Cat. Carabidae, Pars 115, pp. 946, 949, 950 (*C. analis* and *C. coecus*).

Female genitalia: the vaginal palpi usually bear ten spines on the outer margin, one specimen only bearing eleven, and the angle of the latter is very slight as compared to *Chlaenius boisduvali,* Dejean. The nomenclature of this species is in some doubt as this species is confused with *C. coecus,* Dejean. Chaudoir states in 1856 that he considered that Dejean had overlooked the description of *C. analis,* Olivier, when describing *C. coecus,* but later in 1876 states that Olivier's description was so vague that Olivier's figure might denote either *C. sagittarius, C. conformis,* or *C. glabricollis.* I have examined Olivier's original figure and consider that it represents the species whose genitalia I have described.

I have not been able to see the types of either *C. coecus* or *C. analis,* but at present I prefer to retain the name of *C. analis,* Olivier, on the evidence of Olivier's coloured illustration. Fig. 30.

Chlaenius boisduvali, Dejean.

1831. Dejean, Spec. gen. Col. V, p. 625.
1843. Chaudoir, Bull. Soc. Nat. Mosc., **1843** : 751 (*C. plagiatus*).
*1851. Laferte, Rev. Mag. Zool., (2) **3** : 22 (*C. complicatus*).
1856. Chaudoir, Bull. Soc. Nat. Mosc., **1856** : 204.
1861. Wollaston, Ann. Mag. Nat. Hist., (3) **7** : 1861.
1868. Gemminger und Harold, Cat. Col., p. 215.
1876. Chaudoir, Ann. Mus. Civ. Genova, **8** : 52.
*1908. Heyne und Taschenberg, Exot. Kafer, p. 22.
1931. Csiki, Col. Cat. Carabidae, Pars 115, p. 948.

Female genitalia: the vaginal palpi bear from nine to eleven stout spines on the outer margin; the curve of the margin is very pronounced, reaching its apex at the fourth spine from the distal end. The puncturation of the elytra is also quite distinct from that of *C. analis,* Olivier, being very much finer and with a greater number of punctures between the striae. Fig. 31.

Other species which fall into this group are: *C. venator,* Laferte; *C. oculatus,* Fab. (*C. myops,* Dejean); and a specimen in the British Museum determined as *C. fulvipes,* Chaud. In addition I have several undescribed species. With the single exception of *C. fulvipes,* all the species have the characteristic coloration of the elytra, with an irregular orange or yellow patch. (See *C. mirificus,* Pomeroy, Plate I, fig. 3.) *C. fulvipes* is uniformly dark metallic green.

Chlaenius simplex, Wiedemann.

1821. Wiedmann, Germ. Mag. Ent., **4** : 111.
1826. Dejean, Spec. gen. Col. II, p. 340.
1868. Gemminger und Harold, Cat. Col., p. 225.
1876. Chaudoir, Ann. Mus. Civ. Genova, **8** : 67.
1896. Peringuey, Trans. S. Afr. Philos. Soc., **6** : 490, 507.
*1926. ——, Ann. S. Afr. Mus., **23** : 587.
1931. Csiki, Col. Cat. Carabidae, Pars 115, p. 973.

In the group of which *Chlaenius simplex,* Wiedemann, has been chosen as the representative, the vaginal palpi are pointed, but slightly rounded at the apex. There are two strong spines situated towards the base of the outer margin, which are blunt at the tip; a single strong curved spine is situated near the base of the inner margin.

Illustration of female genitalia, Fig. 32.

Several species fall into this group: *C. melancholicus,* Gahan (type examined); *C. kiza,* Alluaud (determined from type); *C. glabricollis,* Dejean; *C. conformis,* Dejean; *C. perspicilaris,* Erichs.; and several others as yet undescribed.

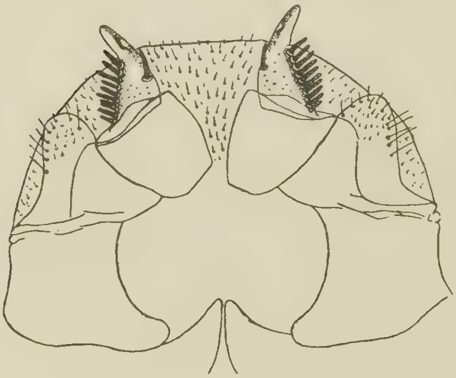


Fig. 30.—*C. analis,* Oliv.

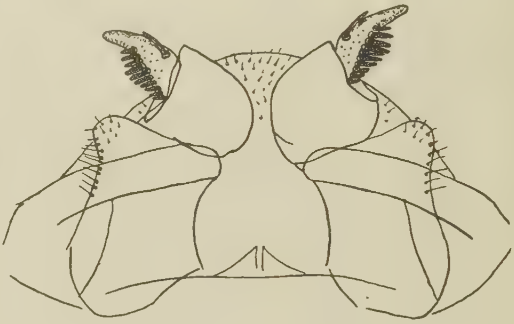


Fig. 31.—*C. boisduvali,* Dej.

Chlaenius cylindricollis, Dejean.

1831. Dejean, Spec. gen. Col. V, p. 637.
1856. Chaudoir, Bull. Soc. Nat. Mosc., **29,** (III) : 226.
1868. Gemminger und Harold, Cat. Col., p. 218.
1876. Chaudoir, Ann. Mus. Civ. Genova, **8** : 107.
1896. Peringuey, Trans. S. Afr. Philos, Soc., **6** : 490, 509.
1902. Marshall, Biology : Trans. Ent. Soc. Lond., **1902** : 382, 390.
1926. ——, Ann. S. Afr. Mus., **23** : 587.
1931. Csiki, Col. Cat. Carabidae, Pars 115, p. 939 (*Chlaeniostenus*).

In the group of which *Chlaenius cylindricollis,* Dejean, has been chosen as the representative, the vaginal palpi are pointed at the end, and bear a single minute spine on the outer margin towards the base, and a long, strong curved spine towards the base of the inner margin. Among the species which appear to fall into this group, may be mentioned the following: *C. denticulatus,* Dejean; *C. angustatus,* Dejean; *C. sellatus,* Dejean; *C. sellatus,* var. *epistrophus,* Alluaud; *C. tenuicollis,* Fab., and numerous other unidentified and undescribed species.

Fig. 33.

Chlaenius columbinus, Dejean. (Pl. I, fig. 1.)

1831. Dejean, Spec. gen. Col. V, p. 666.
1868. Gemminger und Harold, Cat. Col., p. 217.
1876. Chaudoir, Ann. Mus. Civ. Genova, **8** : 174.
1931. Csiki, Col. Cat. Carabidae, Pars 115, p. 950.

In the group of which *Chlaenius columbinus*, Dejean, has been selected as the representative, the vaginal palpi are usually slightly crenulate at the apex, and bear three or four very minute spines at the base of the outer margin, sometimes so small that they are almost vestigial; a single short curved spine is situated near the base of the inner margin. The following species appear to belong to this group, and many more await description: *C. cyanipennis*, Boh.; *C. verecundus*, Peringuey; *C. enonensis*, Peringuey. Fig. 34. Female genitalia.

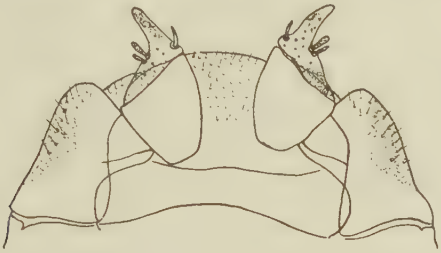


Fig. 32.—*C. simplex*, Wied.

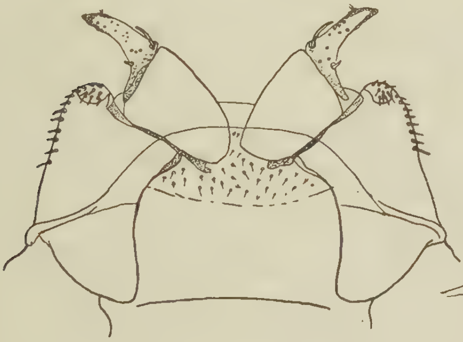


Fig. 33.—*C. cylindricollis*, Dej.

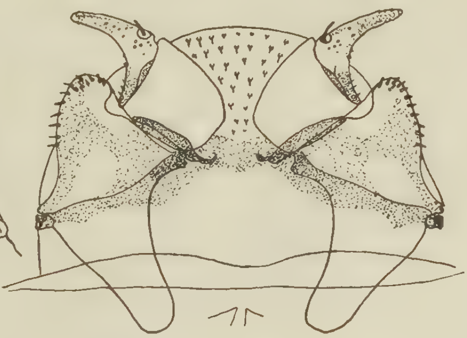


Fig. 34.—*C. columbinus*, Dej.

Chlaenius dusaultii, Dufour.

1821. Dufour, Ann. Sc. phys. Bruxelles, **8** : 359, t. 130, fig. 4 (*Harpalus dusaultii*).
1831. Dejean, Spec. gen. Col. V, p. 619.
1848. Boheman, Ins. Caffraria, I, p. 137.
1864. Motschulsky, Bull. Soc. Nat. Mosc., **1864**, (II) : 342 (*quadrimaculatus* vide Chaudoir *loc. cit.*).
1868. Gemminger und Harold, Cat. Col., p. 218.
1876. Chaudoir, Ann. Mus. Civ. Genova, **8** : 207.
1896. Peringuey, Trans. S. Afr. Phil. Soc., **6** : 491, 515.
*1926. ——, Ann, S. Afr. Mus., **13** : 588, 599.
1931. Csiki, Col. Cat. Carabidae, Pars 115, p. 953.

In the group of which *Chlaenius dusaultii*, Dufour, has been selected as representative, the vaginal palpi are pointed at the distal end, but the outer margin is crenulate and membranous in structure for the greater part of the length; two or more minute spines, often vestigial are present; the inner margin bears a single very short stout spine, often situated in a sunken cavity; the general appearance is quite different from that of *C. columbinus*, Dejean, when seen under a high magnification. *C. subsulcatus*, Dejean, and *C. somereni*, Alluaud (compared with type), may be mentioned in this group, together with other undetermined species numbering about thirty. Female Genitalia: Fig. 35.

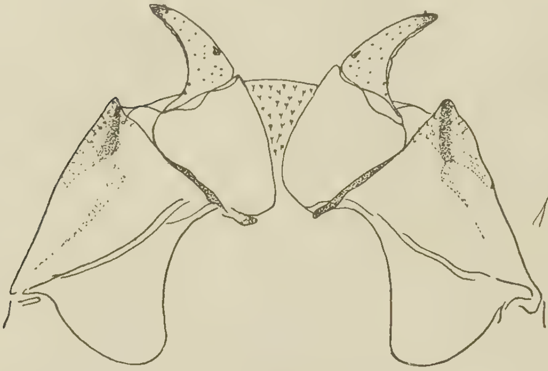


Fig. 35.—*C. dusaultii*, Dufour.

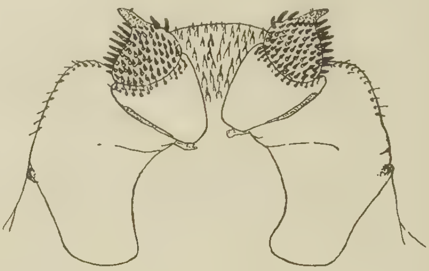


Fig. 36.—*C. similatus*, Boh.

Chlaenius similatus, Boheman.

1848. Boheman, Ins. Caffraria, p. 151.
1868. Gemminger und Harold, Cat. Col., p. 218.
1876. Chaudoir, Ann. Mus. Civ. Genova, **8** : 197.
1896. Peringuey, Trans. S. Afr. Phil. Soc., **6** : 197.
*1926. ——, Ann. S. Afr. Mus., **23** : 586, 596.
1931. Csiki, Col. Cat. Carabidae, Pars 115, p. 973.

The group of which *Chlaenius similatus*, Boheman, has been selected as representative, is most remarkable and unmistakable. The vaginal palpi are rounded and entirely or partially covered with stout spines, like those on a hedgehog; the apex is pointed. Fig. 36.

Hololius nitidulus, Dejean, obviously falls into this group and it is hoped to obtain enough evidence to make this group into a sub-genus. Fig. 37.

Chlaenius ammon, Fab., also belongs among the above species. Fig. 38.

Chlaenius simba, Alluaud.

1929. Alluaud, Bull. Soc. ent. Fr., **1929** : 253.
1931. Csiki, Col. Cat. Carabidae, Pars 115, p. 973 (*Chlaenius*).

Of the large types of *Chlaenius*, *C. simba*, Alluaud (compared with type), is remarkable in the apparent absence of the spine on the inner margin. Fig. 39.

Chlaenius wadelli, Murray.

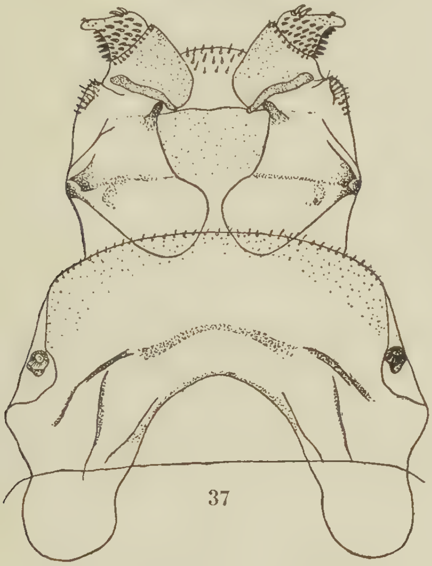
1858. Murray, Ann. Mag. Nat. Hist., (3) **1** : 133.
1868. Gemminger und Harold, Cat. Col., p. 228.
1876. Chaudoir, Ann. Mus. Civ. Genova, **8** : 186.
1931. Csiki, Col. Cat. Carabidae, Pars 115, p. 135.

Chlaenius wadelli, Murray (compared with type), is remarkable in having the vaginal palpi very slender, curved and with a single spine on the inner margin. Fig. 40.

Chlaenius croesus, Fab.

1801. Fabricus, Syst. Eleuth., 1, p. 183 (*Carabus*).
1831. Dejean, Spec. gen. Col. V, p. 667 (*Epomis*).
1868. Gemminger und Harold, Cat. Col., p. 217.
1876. Chaudoir, Ann. Mus. Civ. Genova, **8** : 124 (*Chlaenius*).
*1908. Heyne und Taschenberg, Exot. Kafer, p. 22.
1931. Csiki, Col. Cat. Carabidae, Pars 115, p. 941 (*Epomis*).

Chlaenius (*Epomis*) *croesus*, Fab., lacks any spines on the vaginal palpi, which are crenulate on the outer margin. Fig. 41.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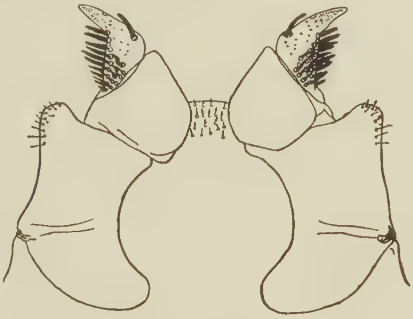
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FIG. 37.—*Hololius nitidulus*, Dej. Chlaeniini.
FIG. 38.—*C. ammon*, Fab.

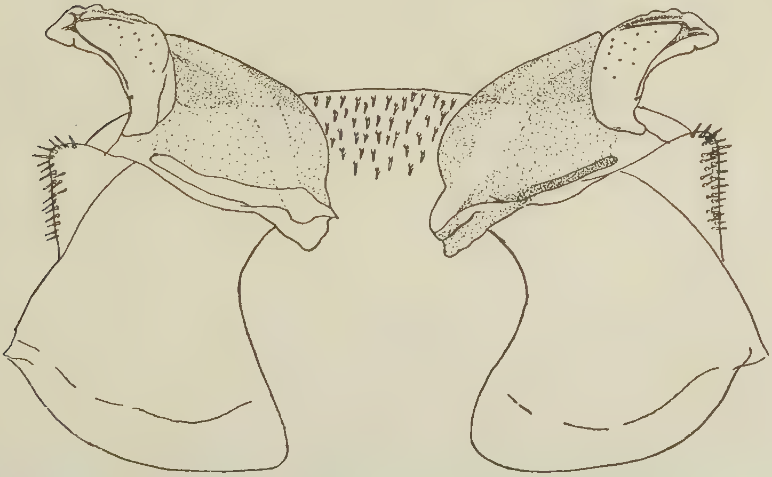
FIG. 39.—*C. simba*, Alluaud.

Chlaenius quadrinotatus, Dejean.

1826. Dejean, Spec. gen. Col. II, p. 299.
1856. Chaudoir, Bull. Soc. Nat. Mosc., **29** (III) : 221.
1868. Gemminger und Harold, Cat. Col., p. 224.
1876. Chaudoir, Ann. Mus. Civ. Genova, **8** : 98.
1931. Csiki, Col. Cat. Carabidae, Pars 115, p. 970 (*Chlaenius*).

Chlaenius quadrinotatus, Dejean, is very interesting, having the vaginal palpi triangular in shape, adorned with three prominent blunt curved spines on the outer margin; a single curved spine is situated on the outer margin. Fig. 42.

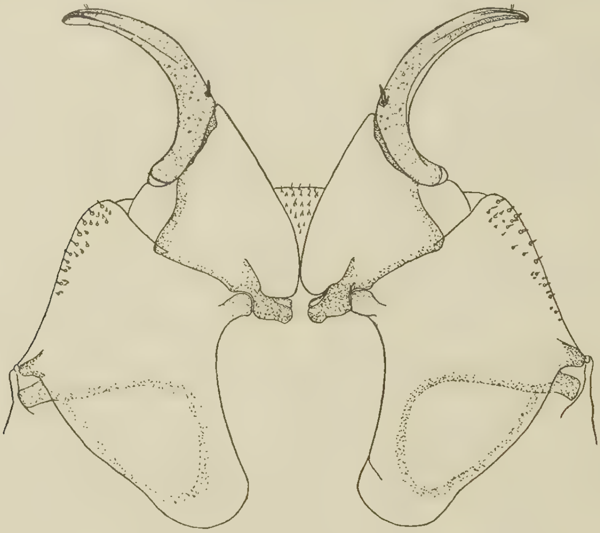

Fig. 40.—*C. wadelli,* Murray.

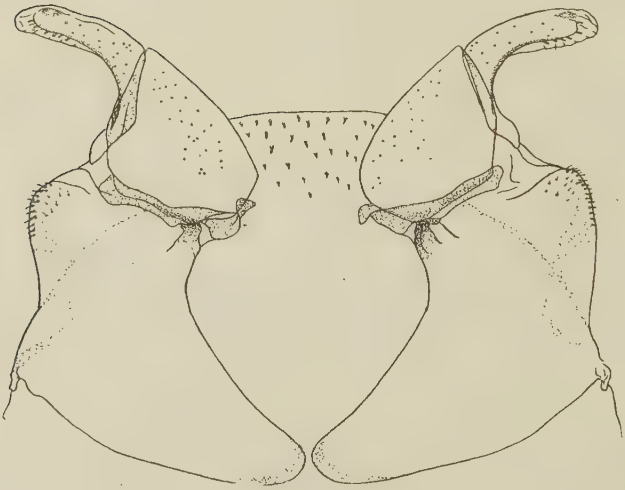

Fig. 41.—*C. croesus,* Fab.

Chlaenius transversalis, Dejean, superficially resembles *C. quadrinotatus,* Dejean, in its appearance and coloration, yet the female genitalia are utterly different in structure, the vaginal palpi being short, rounded and devoid of all adornment with the exception of the two bristles arising from the distal gland at the apex. Fig. 43.

It is hoped that the examples given, together with the illustrations, will support the contention that the female genitalia are of real value in not only separating different species, but also in dividing this large and cumbersome genus into well-defined groups. So far the external characters of the general colour pattern and form of the individuals seem to conform to the arrangement of the species according to the female genital armature. Even in the case of *C. quadrinotatus*, Dejean, and *C. transversalis*, Dejean, the shape of the thorax differs, though the colour pattern is somewhat similar.

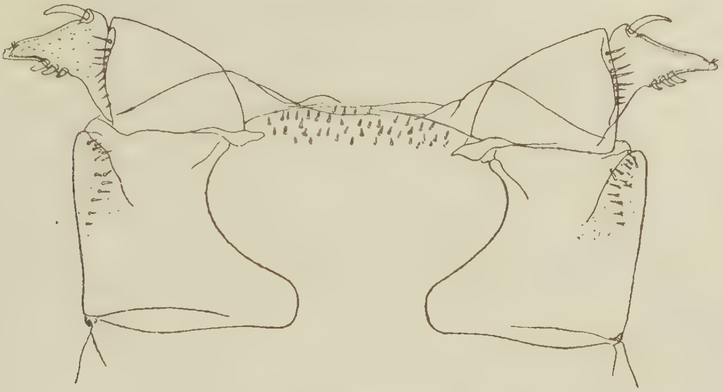

Fig. 42.—*C. quadrinotatus*, Dej.

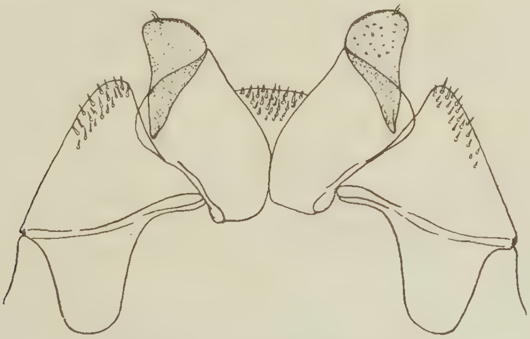

Fig. 43.—*C. transversalis*, Dej.

It is hoped that further study of the species of the genus other than the African ones will afford additional facilities for the arrangement of the genus as a whole.

There are about three hundred and sixty-eight described species of the African Chlaeniines, including synonyms. In addition there has been collected a great deal of material, which is undoubtedly new to science. A system, therefore, which will afford a reliable means of identification and grouping will not only be of value in settling the validity of closely allied species, but also in dividing this huge genus, so that new material can be placed in proper order and synonyms be eliminated.

TABLE SHOWING THE REPRESENTATIVE GROUPS OF AFRICAN *Chlaenius* TO DATE, ARRANGED ACCORDING TO THE FEMALE GENITALIA

(1) *Chlaenius mirificus*, Pomeroy (Type); *C. poultoni*, Pomeroy; *C. analis*, Oliv.; *C. boisduvali*, Dej.; *C. venator*, Laf.; *C. oculatus*, Fab. (*C. myops*, Dej.); *C. analisimilis*, Pomeroy; *C. fulvipes*, Chaud.

(2) *Chlaenius simplex*, Wied. (Type); *C. melancholicus*, Gahan; *C. kiza*, Alluaud; *C. glabricollis*, Dej.; *C. conformis*, Dej.; *C. perspicilaris*, Dej.

(3) *Chlaenius cylindricollis*, Dej. (Type); *C. denticulatus*, Dej.; *C. angustatus*, Dej.; *C. sellatus*, Dej.; *C. sellatus* var. *epistrophus*, Alluaud; *C. tenuicollis*, Fab.

(4) *C. columbinus*, Dej. (Type); *C. cyanipennis*, Boh.; *C. verecundus*, Peringuey; *C. enonensis*, Peringuey.

(5) *C. dusaulti*, Dufour (Type); *C. subsulcatus*, Dej.; *C. somereni*, Alluaud.

(6) *Chlaenius simulatus*, Boh. (Type); *Chlaenius* (*Hololius*) *nitidulus*, Dej.; *C. ammon*, Fab.

(7) *Chlaenius simba*, Alluaud (Type).

(8) *Chlaenius* (*Epomis*) *croesus*, Fab. (Type).

(9) *Chlaenius quadrinotatus*, Dej. (Type).

(10) *Chlaenius transversalis*, Dej. (Type).

In each group there is a quantity of undescribed and unidentified material, which will be treated at a later date.

SECTION 3.

The importance of the Microsculpture of the Elytra in distinguishing closely allied species of Chlaenius.

When seen under a low magnification, the puncturation of the elytra often presents a different appearance when several species are examined, but unless the puncturation can be seen with the aid of transmitted light under a high magnification, it is often impossible to observe the microsculpture surrounding the punctures.

The pattern of the puncturation is very difficult to describe numerically, and an accurate photograph is the most satisfactory method. A small portion of the elytra should be removed transversely, so that the mesal margin is included, and, after clearing in oil of cloves or "diaphanol," mounted in canada balsam. A micro-photograph should be made of a magnification of at least one hundred and fifteen times.

This method gives absolute evidence of the difference in the puncturation, which can be seen at a glance. The two species figured are *Chlaenius mirificus*, Pomeroy, and *Chlaenius poultoni*, Pomeroy. Pl. II, figs. 1–4.

SECTION 4.

Laboratory Methods and Technique.

The last two segments of the abdomen should be cut off with a pair of sharp, curved scissors. These should be first wetted and a small teased pad of cotton wool be placed under the abdomen in order to catch the segments if the latter spring away from the field of the binocular. (Eltringham, *Histological and Illustrative Methods for Entomologists*, p. 34.)

In some cases if the specimen is very dry it is advisable to place it in an ordinary relaxing tin for twenty-four hours. The severed portion of the abdomen is then softened in 10% solution of caustic potash by the application of heat. Ten specimens can be prepared at the same time by placing medium-sized test tubes containing the potash in a water bath. This precaution will prevent the potash from boiling over and eliminate the risk of losing the specimen. When the chitin is sufficiently softened, the non-chitinous parts must be removed. The specimens should be placed for a few minutes in glacial acetic acid, which prevents any further action of the potash. They can be run through the various grades of alcohol in the usual way, immersed for a few minutes in xylol and mounted in canada balsam. Sometimes a bath of clove oil helps to clear the chitin, if the latter is very opaque.

The most convenient method of mounting the preparation is to prepare oblong strips of Bristol-board, measuring 1·5 by 2 centimetres. A circle is then punched in the mount and a cover glass affixed with seccotine. The preparation should be teased out, so that all the structures show clearly, but none of the membraneous parts should be broken, or any portions of the main sclerites distorted. All preparations should be mounted in exactly the same way, *i.e.* with the ventral surface uppermost and the top cover-glass laid lightly on the whole, so that there is no undue pressure on the specimen itself.

The mount is then affixed to the pin bearing the specimen from which the preparation was made, and each mount should bear a number to correspond with the number of the entire beetle, in case the mount should be removed from the pin.

A Simple and Inexpensive Method of accurately figuring Genitalia and other Mounted Structures.

The chief objections to the use of a *camera lucida* are the distortion of the image and the difficulty of correct lighting. On the other hand, the projection apparatus which is generally advertised is very expensive. The following apparatus can be made at the cost of under one pound, exclusive of the microscope used, and is satisfactory for any power, including an oil-immersion lens of one-twelfth.

A box is required, two feet high by about ten inches wide and deep, fitted with a sliding panel at the front and right side. An ordinary compound microscope is tilted back on its axis to a horizontal position, and affixed on the back of the box by resting the legs, or base, into slots. The neck of the microscope fits into a circle made through the base of the box, so that the barrel can be moved up and down for purposes of focussing. A 500-watt electric bulb is screwed at the back of the box, so that it clears the underside of the microscope stage and is in line with the condenser and barrel. If a higher power of bulb is used, it is advisable to insert a petri dish, filled with water, resting on a shelf, between the light and the microscope to prevent undue heating of the lenses.

The whole apparatus is affixed on a shelf in a corner of a room, with a drawing-table below. Two curtains either side and a cover over the top must be utilised, in order to eliminate as much light as possible.

The special " slide " described later is fitted into the mechanical stage and the image is projected down on to the drawing-table. The size of the projected image can be altered when necessary by varying the distance from the mouth of the barrel to the drawing-table and by the use of various lenses. As a rule no eye-piece is needed, but, if used, this can be held in place by a clip. By using a stage micrometer the exact magnification can be obtained. The image is then traced on the drawing-board with a fine pencil. Once the correct outline has been obtained, any embellishments of shading and contour can be made without disturbing the slide by removing the microscope from the slots and using it in the ordinary way. When the apparatus is set for use and it is desired to make a symmetrical drawing of any preparation, any part can be brought into the same magnification and focus or superimposed on any other part with absolute accuracy. Pl. III.

A special slide was made to carry the small mounts by taking two pieces of cardboard, boring a circle in the centre, glueing strips of Bristol-board between the same thickness as the mount, and arranging them so that two diagonal grooves were formed through which the mount could be slipped without touching the cover glasses. Pl. III.

A Method of illustrating an entire Beetle.

It is impossible to obtain a photograph of an entire beetle, giving a magnification of nine times, so that all parts will be in complete focus, owing to the depth of focus involved. A photograph was therefore taken with a magnification of nine times, the focal plane being the middle of the elytra. A leg was bent upwards, so that a portion was in the same focal plane as the centre of the elytra. By stopping down the aperture of the lens to the maximum, and giving the correct exposure, it was possible to get all the body in focus. A print was then made on matt paper. All appendages were then blocked out on the plate and a light print made. The appendages were then removed from one side of the specimen, mounted in balsam on the usual type of mount, placed in the projection apparatus previously referred to, and the image focussed to the exact measurement of the portion of the appendage in focus on the first print. The appendages, legs, palpi, and antennae were then superimposed on the print in outline with a pencil. By clearing the thorax and head of a similar specimen and manipulating the apparatus in the same manner, the exact position of the punctures could be delineated.

The print was then coloured with ordinary water-colours, with a light wash for the translucent effects and opaque tints on the darker portions. The advantage of this method is the production of an illustration in a short space of time, which is absolutely accurate with regard to form and scale. Pl. I, figs. 1–4.

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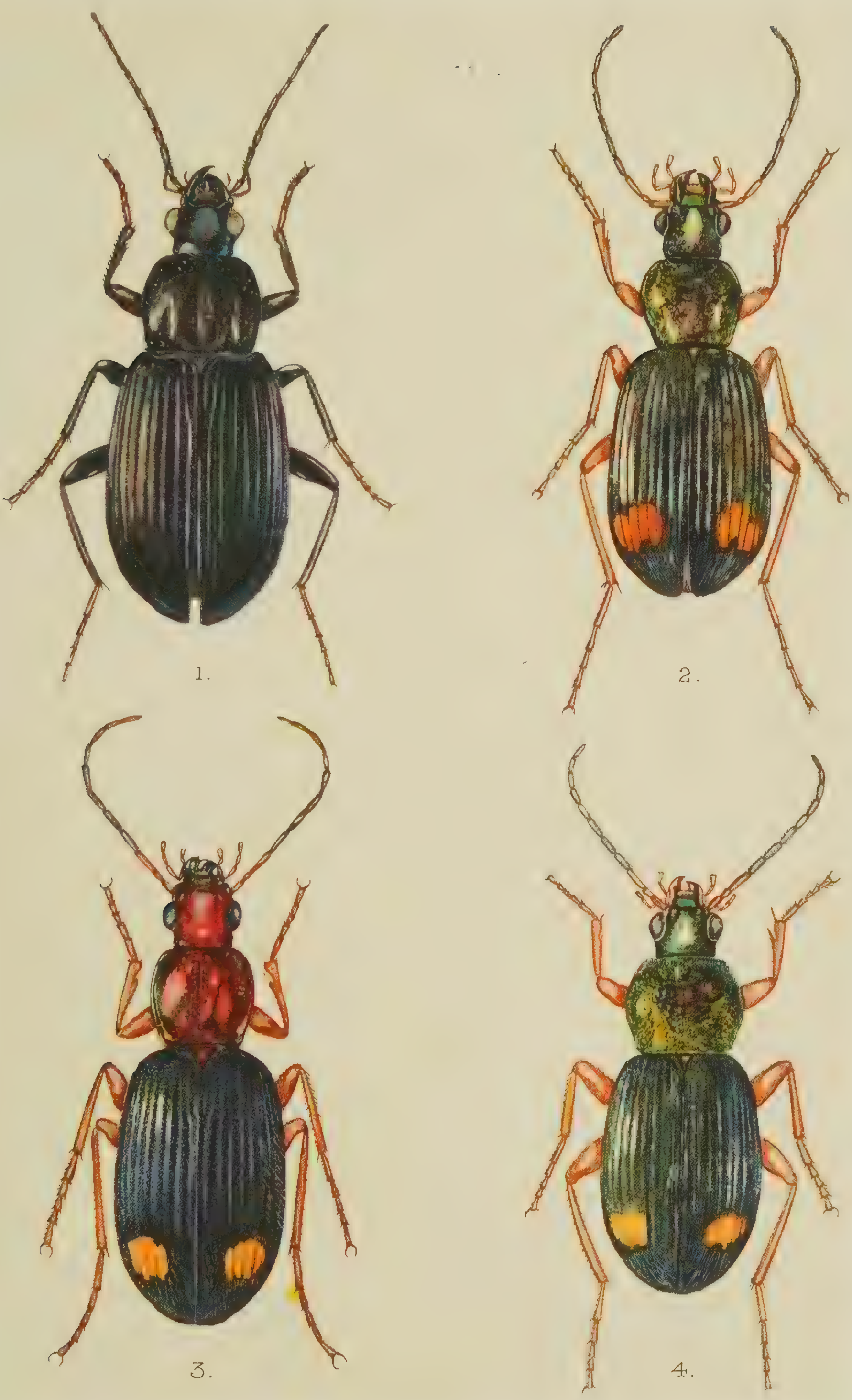
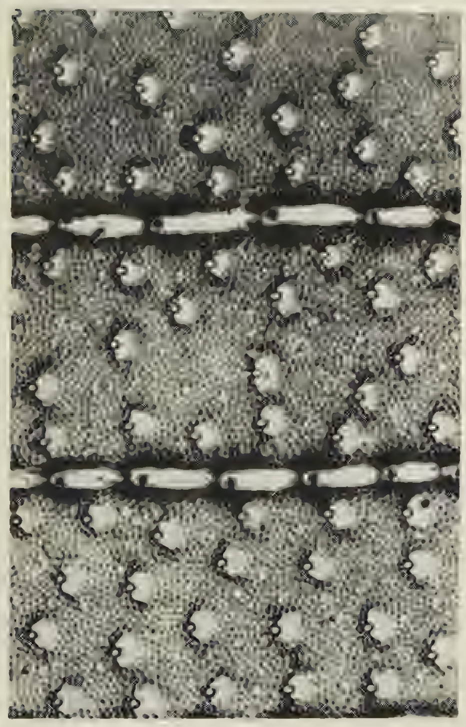


A.W. J. Pomeroy. Pinx.
John Bale, Sons & Danielsson Ltd London

Fig. 1. *CHLAENIUS COLUMBINUS*, Dej. × 4; fig. 2. *C. POULTONI*, Pomeroy. × 4; fig. 3. *C. MIRIFICUS*, Pomeroy. × 4; fig. 4. *C. ANALISIMILIS*, Pomeroy. × 4.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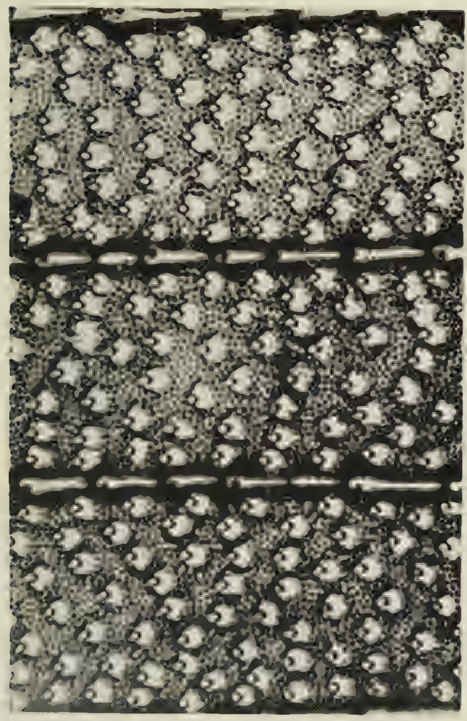
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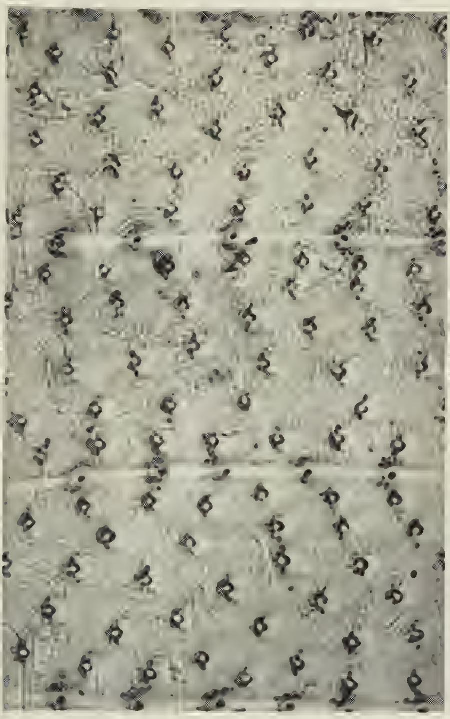
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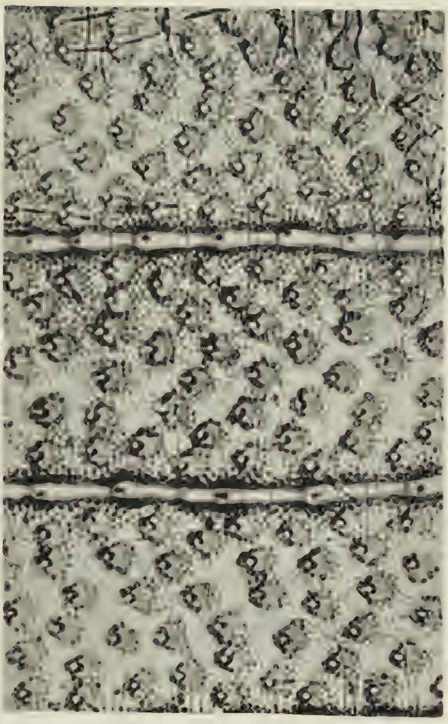
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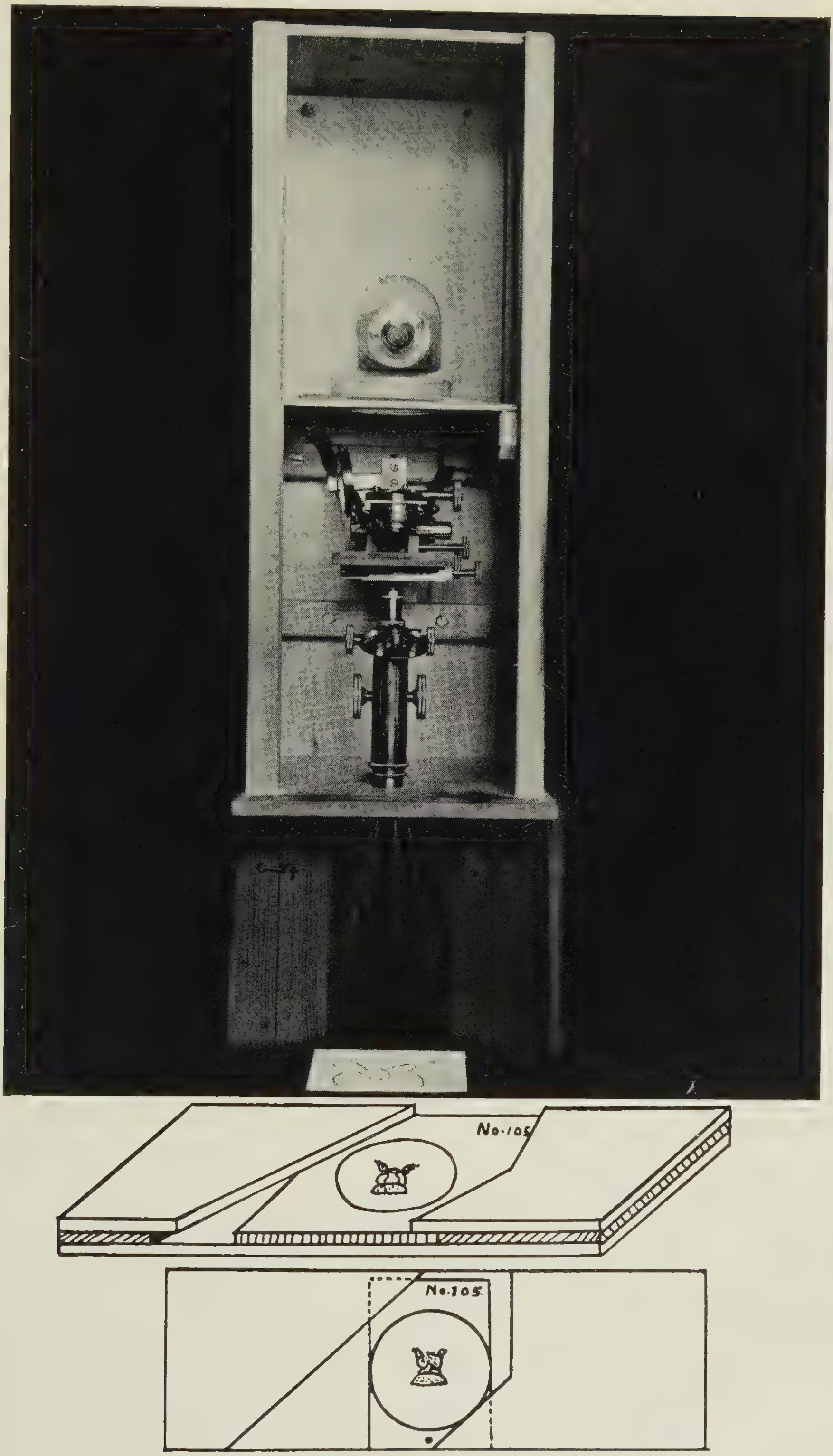
Integument of elytra of, fig. 1, *Chlaenius mirificus*, **Pomeroy; fig. 2,** *C. poultoni*, **Pomeroy; fig. 3,** *C. analis*, **Oliv.; fig. 4,** *C. analisimilis*, **Pomeroy.**

All figures are X c.90.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A simple method of figuring genitalia.

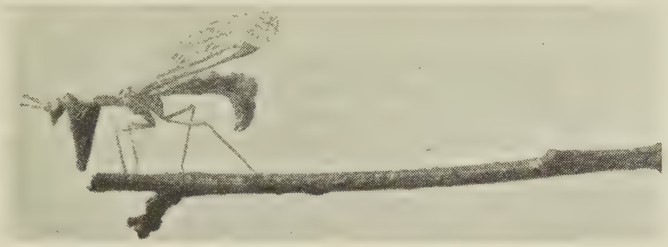
ON AN EXTRUSIBLE GLANDULAR STRUCTURE IN THE ABDOMEN OF *MANTISPA STYRIACA*, PODA (NEUROPTERA)

By H. Eltringham, M.A., D.Sc., F.R.S.

[Read 2nd December, 1931.]

With Plate IV and One Text-figure.

In the course of his observations on the life-history of *Mantispa styriacah*, my friend Mr. Hugh Main noticed that the male of this curious insect possesses an extrusible organ on the dorsal surface of the abdomen, to which he called attention when giving an account of the insects, illustrated by very beautiful photographs, at a meeting of the Entomological Society on March 4th, 1931.



Photograph, by Mr. Hugh Main, of a male *Mantispa styriaca*, seated on a twig. The raptorial fore-legs are folded up, and the extrusible organ can be seen as a swelling on the hinder dorsal part of the abdomen.

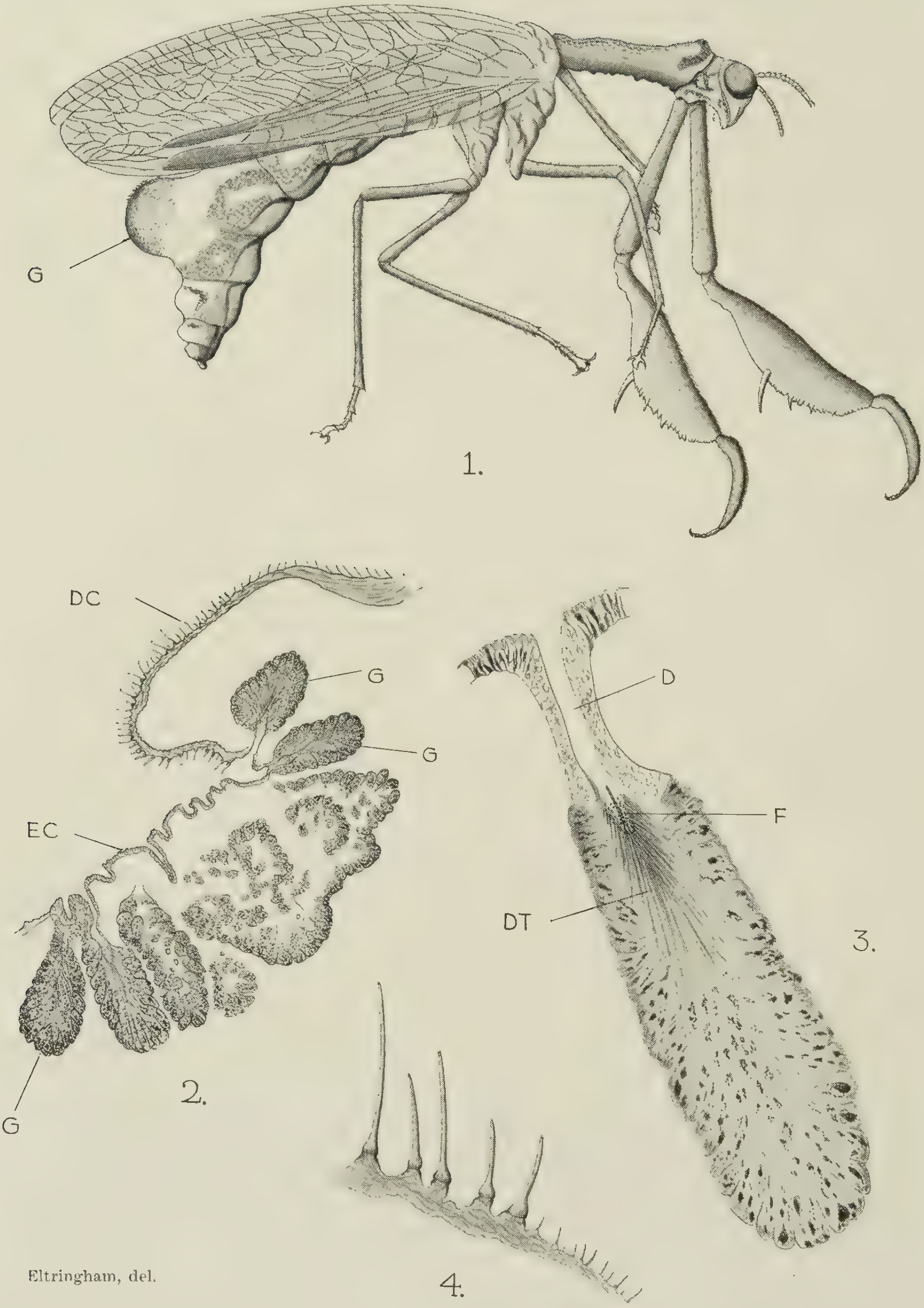
[1931, *Proc. Ent. Soc. Lond.*, **6** : 26 (footnote).] On a further expedition to the South of France he secured a number of pupae and very kindly entrusted to me some of the resulting imagines for histological examination. The accompanying text-figure is from a photograph of the living insect.

I was able to make a few interesting observations while the insects were still alive. The organ is situated dorsally in the fourth and fifth abdominal segments. Occurring in the male only, one must assume that it is sexual in function and probably excretes some aphrodisiac odour, though I was not able to detect any scent which came within my own olfactory range. The gland is, however, very much in evidence when the insect is feeding. Any small insect such as a fly, is seized by the raptorial fore-legs, the movement being so rapid that it can scarcely be seen. The prey is held in a vice-like grip between the highly modified tarsi and the dentate tibiae. It is then ruthlessly eaten alive, the powerful mandibles working with great rapidity. Swallowing seems to take place continuously, accompanied by considerable movement of the abdomen. During this process the extrusible organ swells up and contracts with a certain degree of regularity, suggesting a rhythmic variation of the internal fluid pressure, probably due to peristaltic movements of the viscera.

I had hoped to induce a pairing of the insects so that the accompanying action of the organ, if such occurs, could be observed. A male and female, after feeding, were enclosed in a glass box. The organ was extruded at regular intervals, but rather less frequently than when feeding. The male approached the female with great caution, extending, waving, and retracting the fore-legs all the time, as though to impress the female with his identity. Remaining at a distance which he could just bridge with his fore-legs, extended to their utmost, he tapped her lightly with one of his fore-tarsi, whereupon she grabbed at him with her raptorial legs. He avoided the danger by a very rapid backward movement. This performance was repeated several times, always accompanied by a vigorous waving of the fore-legs, and the occasional extrusion of the abdominal organ. Sometimes the female, instead of attacking, turned away and seemed quite indifferent to the male's advances. When this occurred he cautiously followed her to within touching distance. I watched these manœuvres for fifteen to thirty minutes on several occasions, but they never progressed any further than tentative advances, the male always ultimately turning away and ceasing to take any further interest.

My specimens did not seem to preserve their vitality very well, and as I wished to make a successful histological examination of the gland, and feared that some disease might supervene and impair the normal cytological structure, I transferred them to preservatives, ultimately embedding in wax and preparing series of sections.

Plate IV, fig. 1, is a sketch of the whole insect as it lay in a watch glass. Its total length is about 18 millimetres from the head to the end of the abdomen. I have shown the gland in a partly expanded condition at G. In its retracted position it is scarcely noticeable. It consists essentially of two parts, a distributive area formed by a deep fold of the posterior cuticle of the dorsal part of the fourth segment, and a glandular portion, which is the modified anterior part of the fifth segment. Fig. 2 is a reflector drawing of a section through the whole organ. DC is the fold, partly expanded. It is furnished with smooth rather blunt hairs, or papillae, five of which are shown much enlarged in fig. 4. These structures, under very high magnification, appear to be open at the ends, a most unusual formation, suggesting that some of the glandular secretion may be drawn into them by the force of capillarity. They form the distributing or diffusing apparatus. The expansion of the organ is no doubt effected by internal fluid pressure, and there are numerous retractor muscle fibres, not reproduced in the drawing. The glandular portion is relatively very large, and consists of a great number of separate multicellular glands, each of which opens through a duct. The external orifices of the ducts are distributed over the surface of an elastic cuticle, EC, covering the anterior dorsal and dorso-lateral areas of the fifth segment. Three of these glands are indicated at G, G, G, fig. 2. They have a complicated structure. One of them, more highly magnified, is shown in fig. 3. The secreting cells are not very characteristic. Stained with iron-haematoxylin they show a greyish, slightly granulated cytoplasm with occasional faint striation. The nuclei are ill-defined and difficult to distinguish from numerous aggregations of darkly-staining granules scattered throughout the structure. Every cell has a fine ducteole, and these ducteoles, DT, lead to the funnel-shaped base F, of the main duct D. The funnel-like structure is small in comparison with the great number of cells, and it seemed scarcely possible that each ducteole can have an independent opening into it, but I can find no certain example of anastomosis of the ducteoles. In some sections, though not in all, there is a curious bristle-like structure projecting from the base of the funnel and extending for a short distance into the lumen of the duct. It may be a relic of the embryonic invagination of the duct.


G
1.
DC
G
G
EC
G
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D
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DT
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Eltringham, del.

Extrusible Organ in *MANTISPA STYRIACA*

The whole organ is large and complicated in comparison with the size of the insect, and whatever may be its function, it must be of great importance. I know of no other insect gland to which it bears any close resemblance.

EXPLANATION OF PLATE IV.

FIG. 1. General view of the male *Mantispa styriaca.* The extrusible organ is seen partly extended at G.

2. Section through part of the glandular organ. DC, the fold of the fourth segment, partly expanded, with the distributing hairs or papillae. EC, the eversible cuticle on the surface of which the ducts of the glands open. G,G,G, three of the multicellular glands.

3. One of the glands more highly magnified. (Actual length ·3 mm.) D, the duct. F, the funnel-like base of the duct into which open the ducteoles, DT, which convey the secretion from the numerous cells of the gland.

4. A small part of the distributive fold of the fourth segment, with five of the papillae.

ENTOMOLOGICAL EXPEDITION TO ABYSSINIA, 1926-7. MICROLEPIDOPTERA

By Edward Meyrick, B.A., F.R.S.

[Read 2nd March, 1932.]

I am not acquainted with any previous records of Microlepidoptera from Abyssinia. Just 50 species are included in the present collection. The specimens from Jem-Jem Forest were collected partly by Dr. Hugh Scott and partly by Mr. J. Omer-Cooper, those from other localities were all taken by Dr. Scott. As these were collected almost entirely above 8000 feet, it is not surprising that 42 are new to science; there are also 3 new genera. The types are in the British Museum.

Dr. Scott, in a private letter to me, describes the localities as follows: "Mount Chillálo, in the Arussi country, east of Lake Zwai, is particularly interesting; there is a forest belt on it from about 8000 to 10,000 feet, and above that desolate heath-land up to about 12,000 or 13,000 feet (the summit), one of the most desolate places I ever was in; the heath is *Erica arborea*; 10,000 feet is the tree-limit. Mount Zukwala is another very interesting place, an isolated extinct volcanic cone, rising from a plain at about 7000 feet to 9600 feet, with a circular lake in its crater; the walls of the crater covered with grass dotted with tree-heath, and patches of forest and scrub (forest of giant *Juniperus*). Jem-Jem Forest, about 45 miles west of Addis Ababa, is a dense forest composed mainly of lofty conifers, *Juniperus procera* and *Podocarpus*, but with a great variety of other trees and bushes, and open grassy and flowery glades. The Muger Valley is quite different, being about 5500 feet elevation (at the bottom), with precipitous sides rising to 8000 feet; down in the valley it is hot and stuffy, and there is *Acacia* thorn-scrub, &c."

Of the 8 apodemic species, the *Polyhymno* is indeterminable, but the genus is mainly African. *Platyptilia morophaea* was found on Mt. Kenya, and *Stenoptilia petraea* is an alpine species taken in Africa at Nairobi, and known also from Ceylon, India, and China. *Lobesia aeolopa*, *Blastobasis industria*, and *Tinea othello* are doubtless spread by human agency. *Eucleodora chalybeella* and *Brenthia leucatoma* are African species of unrecorded habit, but not improbably associated with some cultivated plant.

The 42 endemic species are on the whole of African character, mountain representatives of genera found also at lower elevations. The most striking exception is *Plutella*, of which three species were found on Mt. Chillálo, forming a disproportionate element in its fauna. The genus is world-wide, with endemic species in all regions (including Spitzbergen, Hawaii, and New Zealand), and a preference for temperate climates, but only 32 species are known hitherto, and three new species from one mountain is something quite exceptional. Only two other African species have been described, one from Cape Colony and one from Tripoli,* and the three Abyssinian species appear most allied to those inhabiting Central Europe. The original home of *Plutella* is probably the southern end of South America, and its distribution, emphasised by its distinctness, is very curious. In the present case it seems almost certain that the immigration was from Europe, and that it could only have taken place during a glacial period.

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* Since writing this, I have described another species from Mt. Ruwenzori, Uganda, at 12,000 feet, which is obviously allied to these Abyssinian forms.

Stenoptilia tyropiesta and *Oxyptilus esuriens* are also obviously of European affinity, and probably of contemporary origin.

Tinissa is a characteristically Indo-Malayan genus, but one African species is already known; there is, however, no question that this and the Abyssinian species must have been derived from India.

With these exceptions, the Abyssinian insects do not appear to be alien in type to the general African fauna.

PTEROPHORIDAE.

Oxyptilus esuriens, sp. n.

♂. 16 mm. Head, thorax dark fuscous somewhat sprinkled whitish. Palpi slender, obliquely ascending, dark fuscous, with incomplete whitish rings. Fore-wings cleft to middle, lobes narrow, first pointed, acute, second with termen long, extremely oblique, slightly sinuate; dark coppery-fuscous; fine whitish marks on edges of first lobe at $\frac{1}{3}$ and two or three whitish specks at $\frac{2}{3}$: cilia grey irregularly mixed dark grey, two or three white scales on costa and within cleft at $\frac{1}{3}$ and $\frac{2}{3}$ of lobes and on both sides of base of second lobe, slight whitish bars on each side of apex, some ochreous-whitish suffusion above tornus and on dorsum towards tornus, leaving a rather dark grey tornal patch, a moderate blackish dorsal scale-tooth rather before cleft and a small one beyond cleft. Hind-wings dark fuscous; cilia grey, a moderate dark fuscous scale-tooth on both margins of third lobe almost at apex, followed by one or two white scales.

Jem-Jem Forest, 8000 feet, October; 1 ex.

Platyptilia amblydectis, sp. n.

♂. 22 mm. Head reddish-brown, face with moderate conical tuft. Palpi moderate, obliquely ascending, second joint rather expanded with loose scales, dark reddish-fuscous, terminal joint short, tip whitish. Thorax rather dark reddish-fuscous. Fore-wings cleft to $\frac{2}{3}$, lobes moderate, rather dilated, apex subfalcate, termen first lobe sinuate, oblique, second slightly bowed, oblique; reddish-fuscous transversely strigulated whitish; a blackish-fuscous triangular costal blotch at $\frac{2}{3}$, its apex acutely projecting just before cleft, its anterior angle projecting as a fine costal streak marked three or four minute whitish strigulae to before middle, a small dark brown spot beneath its extremity, blotch posteriorly edged white suffusion widest on costa; a dark brown fascia crossing middle of both lobes, edged posteriorly by a white streak: cilia on costa fuscous, on termen brownish-whitish, base brownish within a black subbasal line shortly interrupted beneath apex of second lobe, within cleft light grey becoming dark fuscous near angles of lobes, on dorsum grey mixed whitish basally, with large blackish scale-tooth at $\frac{3}{5}$, and small one beneath base of cleft. Hind-wings dark grey; cilia dark grey, with slight reddish-tinge, on dorsum of third lobe with scattered black subbasal scales from base to near middle, a distinct basal whitish tinge in middle, and a rather elongate obtuse-triangular scale-tooth of black-tipped scales beyond middle.

Jem-Jem Forest, 8000 feet, October; 2 ex. Nearest *acanthodactyla* and *picta*, but in both these the scale-tooth of hind-wings is acute.

Platyptilia morophaea, Meyr.

Jem-Jem Forest, 8000–9000 feet, September; 1 ex. Only recorded from Mt. Kenya.

Platyptilia daemonica, sp. n.

♂. 26–28 mm. Head, thorax ochreous-whitish, face with short cone of scales. Palpi long, obliquely ascending, second joint with roughly expanded hair-scales beneath, fuscous becoming whitish towards apex. Fore-wings cleft to ¾, lobes moderately broad, apex pointed, prominent, termen first lobe sinuate, oblique, second rounded, very oblique; ochreous-whitish, a few scattered grey or fuscous scales, costa sometimes suffusedly irrorated dark fuscous anteriorly; a well-marked blackish dot in disc at ⅓, and two transversely placed a little before cleft, lower slightly anterior; an irregular-edged pale greyish terminal streak, slightly sprinkled blackish-grey: cilia ochreous-whitish, on costa a short dark grey basal line towards middle of first lobe and a small fuscous mark near apex, on termen a dark grey subbasal line, on dorsum two short black basal scale-teeth. Hind-wings light grey; cilia whitish, a grey subbasal shade round first lobe, and blackish dots at apex of second and third, on dorsum a black subbasal streak of scales from base to about ¾, somewhat interrupted at middle of wing.

Jem-Jem Forest, 8000 feet, October; 5 ex. Nearest to *sabia*, but distinct by whitish colouring, less falcate fore-wings, and black scale-teeth in dorsal cilia of fore-wings.

Platyptilia implacata, sp. n.

♂. 26–28 mm. Head, thorax brownish mixed fuscous, thorax posteriorly irrorated blackish. Palpi moderately long, obliquely ascending, second joint with scales rather expanded, brownish mixed fuscous. Fore-wings cleft to ⅔, lobes rather narrow, apex pointed, termen first lobe sinuate, rather oblique, second very obliquely bowed; fuscous suffused darker towards costa and posteriorly; an obscure suffused dark fuscous dot in disc before ⅓; two suffused blackish-fuscous dots transversely placed near before cleft, lower slightly anterior; the dark suffusion sometimes forms indistinct cloudy subterminal markings: cilia on costa dark fuscous, tips lighter, a suffused light brownish-ochreous spot towards apex, on termen dark grey, on dorsum and in cleft grey, somewhat sprinkled blackish scales. Hind-wings dark grey; cilia grey, on dorsum irregularly strewn black-tipped scales from base to ⅔, interrupted at middle of wing and beyond this forming a short sinuate tooth projecting furthest anteriorly.

Jem-Jem Forest, 8000 feet, October; 2 ex. Nearest *maligna*, but much larger, and without the three pale dots in costal cilia of fore-wings, of which the first and third, though termed pale ochreous in my description, are really white and very distinctive.

Stenoptilia petraea, Meyr.

Mt. Chillálo, 10,000 feet, on moorland, November, 1 ex.; a very worn specimen from Jem-Jem Forest, 8000 feet, September, is probably the same species.

Stenoptilia tyropiesta, sp. n.

♂. 23 mm. Head, thorax ochreous-brownish, face with moderate horny cone, a fine white line above eye. Palpi ochreous, apical edge sprinkled white. Fore-wings apex acute-pointed, angle of first lobe wholly absent, termen of second straight, very oblique; ochreous-brownish, becoming ochreous-yellowish on dorsal half and tinged whitish dorsally posteriorly; extreme costal edge tinged whitish from about middle to ⅘; a very few minute scattered black specks in disc: cilia light grey, base finely white on termen. Hind-wings grey; cilia light grey.

Mt. Chillálo, 10,000 feet, on moorland, November; 1 ex. Allied to *pterodactyla* and *megalochra*.

PHALONIIDAE.

Trachybyrsis chionochlaena, sp. n.

♂. 18 mm. Head white. Palpi white, suffused grey towards base. Thorax grey somewhat marked blackish. Fore-wings elongate-triangular, costa moderately arched towards obtuse apex, termen obliquely rounded; white; basal $\frac{2}{5}$ dark grey irregularly marked black in disc, continued on dorsal half by an irregular grey area mixed white and sprinkled black to $\frac{2}{3}$; from termen above tornus a narrow slightly excurved dark grey transverse fascia partially suffused deep ferruginous and marked black on margins to near costa; a small deep ferruginous spot on apical end of costa becoming black at apex, two triangular black dots on termen beneath apex, and some grey scales round them: cilia pale grey, an obscure whitish median line edged blackish anteriorly round apex. Hind-wings light grey, slightly mixed whitish, with some obscure darker strigulae; cilia whitish, a pale grey subbasal shade.

Mt. Chillálo, 9000 feet, in forest, November; 1 ex. Has the aspect of a *Phtheochroa*, with which it probably indicates the true genetic connection.

TORTRICIDAE.

Capua spilonoma, sp. n.

♂. 19 mm. Head, palpi, thorax light ochreous. Fore-wings rather elongate, slightly dilated, costa anteriorly moderately arched, without fold, posteriorly nearly straight, apex obtuse-pointed, rather prominent, termen sinuate, little oblique; light ochreous, sprinkled ochreous-brownish dots and small strigulae, those near costa dark fuscous; basal patch hardly otherwise indicated; central fascia on costa forming an oblique dark grey blotch edged blackish, remainder very oblique, rather narrow, ill-defined, irregular, ochreous-brown, anteriorly with rounded-obtuse prominence below middle, dorsally obsolescent; costal patch small, dark grey, round, and partly edged blackish anteriorly; some grey strigulation on apical end of termen: cilia pale yellow-ochreous, a grey apical bar. Hind-wings grey-whitish, small scattered greyish spots; cilia grey-whitish.

Jem-Jem Forest, over 8000 feet, October; 1 ex. Allied to *liparochra*, but distinct by prominent apex of fore-wings.

Tortrix ophiograpta, sp. n.

♂. 21–22 mm. Head, palpi, thorax greyish-ochreous. Fore-wings suboblong, moderately broad, costa anteriorly strongly arched, without fold, posteriorly nearly straight, apex nearly rectangular, termen faintly sinuate, little oblique; greyish-ochreous; markings ochreous-brown, finely and indistinctly pale-edged; basal patch moderate, edge little oblique, excavated beneath costa and on fold; central fascia moderately broad, oblique, anterior edge bisinuate, strongly convex-prominent below middle, posterior edge slightly convex-prominent on median third; costal patch rounded-triangular, suffused dark brown beneath: cilia light greyish-ochreous, basal and median brown shades. Hind-wings light grey; cilia pale greyish-ochreous.

Jem-Jem Forest and Mt. Chillálo, 9000 feet, October, November; 2 ex. Allied to *dinota*.

Tortrix diametrica, sp. n.

♂. 20–21 mm. Head, thorax light fuscous. Palpi 3, pale fuscous, irrorated darker, interiorly whitish. Fore-wings moderate, suboblong, costa anteriorly moderately arched, without fold, posteriorly slightly arched, apex obtuse, termen slightly sinuate, hardly oblique; pale fuscous, some scattered dark fuscous scales; basal patch only indicated by slight darker suffusion; central fascia straight, narrow, oblique, fuscous, mixed dark fuscous and blackish, in middle somewhat mixed reddish-brown, dorsally obsolescent; costal patch large, semioval, fuscous, mixed dark fuscous on lower edge: cilia pale fuscous. Hind-wings light grey; cilia whitish-grey, a dark grey subbasal line.

Jem-Jem Forest, 8000 feet, October; 2 ex. Allied to the following.

Tortrix physetopa, sp. n.

♂♀. 16–18 mm. Head, thorax pale brownish-ochreous. Palpi 3, dark fuscous, ♂ second joint internally with long expansible ochreous-whitish hairs. Fore-wings moderate, somewhat dilated, costa anteriorly moderately arched, ♂ with costa slightly reflexed on basal ¼, with short flap of appressed projecting scales near base, apex obtuse-pointed, termen slightly sinuate, rather oblique; light greyish-ochreous with slight indistinct fuscous strigulation; basal patch hardly indicated; central fascia moderate, oblique, edges slightly sinuate, posterior edge suffused on lower half; costal patch moderate, semioval, sometimes one or two strigae from this to lower part of termen: cilia whitish-ochreous, a faint greyish antemedian line. Hind-wings grey; cilia whitish-grey, a grey subbasal shade.

Jem-Jem Forest and Mt. Chillálo, 8000–9000 feet, October, November; 5 ex. Doubtless related to *prona*.

EUCOSMIDAE.

Eucosma vulpecularis, sp. n.

♂. 13 mm. Head pale ferruginous-ochreous, two or three blackish scales on forehead. Palpi light ochreous suffusedly mixed dark fuscous. Thorax ferruginous, a blackish streak on each side of back. Fore-wings elongate-triangular, costa slightly arched, without fold, termen somewhat bowed, rather oblique; ferruginous; costa marked with obscure fine grey or blackish strigulae from about ¼ to ¾, edge obscurely whitish between these; an undefined expanding median band of dark grey suffusion from base to middle, beyond this some cloudy grey and whitish suffusion to ⅔; two very oblique leaden strigae from beneath costa disconnected by obscure fine blackish-grey dashes from two erect leaden streaks enclosing ocellus, slight whitish suffusion within ocellus and beyond it; small obscure whitish spots at apex, and on costa before it: cilia grey, a blackish basal line edged whitish posteriorly. Hind-wings 3 and 4 coincident; grey, veins and termen somewhat darker-suffused; cilia whitish-grey, anteriorly more whitish with dark grey subbasal line.

Jem-Jem Forest, 8000 feet, October; 1 ex.

Eucosma picrodelta, sp. n.

♂. 21 mm. Head ochreous-white, front of collar black. Palpi black, apex of second joint white, terminal joint white with a black dot. Thorax white (rubbed dorsally), base of tegulae black. Fore-wings elongate, posteriorly dilated, costa slightly arched, without fold, apex obtuse-pointed, termen hardly sinuate, rather oblique; white, some small scattered black dots; basal patch represented by an elongate blackish interrupted costal blotch from base, and a triangular blackish dorsal blotch about ¼, reaching above fold; three suffused blackish dots on costa beyond this, a small black triangular spot in middle, and three smaller transverse marks between this and apex; an acute-triangular blackish praetornal spot; a narrow somewhat irregular black streak along upper ⅔ of termen; an irregular series of four or five small black dots denoting interior of ocellus: cilia dark grey, on costa and tornus white. Hind-wings 3 and 4 stalked; grey, slightly darker posteriorly; cilia pale grey.

Jem-Jem Forest, over 8000 feet, October; 1 ex.

Lobesia aeolopa, Meyr.(?).

Jem-Jem Forest, 8000 feet, October; 1 ex. The specimen is a ♀, and as the species of this genus are sometimes extremely similar and apparently indistinguishable in this sex, the identification cannot be positive without the observation of a male; this latter sex affords good characters.

Argyroploce polymorpha, sp. n.

♂♀. 16–18 mm. Head, palpi, thorax dull greyish-ochreous, partially or more often wholly suffused dark fuscous. Fore-wings rather elongate, gradually dilated, costa gently arched, apex obtuse, termen slightly sinuate, little oblique; white, but more often largely mottled or wholly suffused dark grey; basal patch moderate, edge strongly angulated in middle, in the example with clear white ground-colour extended by a broad costal lobe to beyond middle; in one example a broad irregular blackish blotch occupying dorsal half from close beyond basal patch to near tornus; in one example the white colour appears only as a broad suffused fascia from costa beyond middle to tornal area; in two examples with general dark suffusion no markings are definable: cilia grey, in the whitest specimen slightly mixed white suffusion. Hind-wings ♂ without special characters; grey, ♀ slightly darker; cilia grey, a darker subbasal shade.

Jem-Jem Forest, 8000–9000 feet, September, October; the single ♂ on "Maskal" flowers (*Coreopsis* and *Guizotia* sp.); 7 ex. The variation is so great that it is difficult to include all the forms under one description, but all agree entirely in structure; I have no doubt that all are truly conspecific; it may be presumed that the single whitest specimen represents the primitive type, the other forms being produced by a varying development of dark suffusion.

Argyroploce aegidia, sp. n.

♂. 20 mm. Head, palpi, thorax greyish-ochreous, partially suffused grey. Fore-wings rather elongate, posteriorly dilated, costa gently arched, termen nearly straight, hardly oblique; grey irregularly strigulated and reticulated dark fuscous; about ten small blackish spots along costa; an irregular rather darker grey median fascia edged or mixed blackish from dorsum parallel to termen, not reaching costa; a similar blackish grey-sprinkled fascia from before tornus, reaching ¾ across wing: cilia grey mixed blackish. Hind-wings without special characters, rather dark grey; cilia light grey, a darker subbasal shade.

Jem-Jem Forest, 9000 feet, October; 1 ex.

Argyroploce maschalista, sp. n.

♂♀. 18–21 mm. Head, palpi, thorax greyish, somewhat mixed dark fuscous. Fore-wings rather elongate, posteriorly dilated, costa gently arched, termen faintly sinuate, hardly oblique; grey, irregularly and suffusedly mixed dark fuscous, forming undefined darker clouds; indistinct somewhat oblique transverse spots of whitish suffusion from before and beyond middle of dorsum; a small white dot on end of cell; about ten small dark fuscous costal spots: cilia grey, a darker subbasal shade. Hind-wings ♂ with basal part of dorsum thickened and projecting as a slender lobe to below middle; rather dark grey; cilia light grey, a darker subbasal shade. Posterior tibiae ♂ with slender black hair-pencil in an interior groove on basal half.

Jem-Jem Forest, 8000–9000 feet, October; 5 ex. This belongs to the group separated by some as a distinct genus (in my judgment unadvisedly) under the name *Exartema*, Clem.; it is a type prominent in North America.

Laspeyresia calliglypta, sp. n.

♀. 10 mm. Head blackish-grey sprinkled ochreous-whitish. Palpi whitish somewhat sprinkled blackish-grey. Thorax dark grey. Fore-wings rather elongate-triangular, costa almost straight, termen slightly rounded, somewhat oblique; dark fuscous; basal area mostly suffused leaden-grey, extended on dorsal area to ⅔; between ¼ and apex six short rather thick direct prismatic whitish streaks from costa; a direct iridescent grey-whitish streak from dorsum beyond middle reaching more than half across wing, beyond apex of this an irregular white discal blotch, slightly yellowish-tinged anteriorly, edged black beneath; ocellus narrow, black crossed by three or four striae of yellowish irroration, enclosed by two bright violet-golden or coppery-metallic lines, second extended along termen almost to meet last costal streak: cilia grey, round apical area prismatic-whitish with base black. Hind-wings light ochreous-yellowish, a broad irregular suffused dark fuscous terminal fascia; cilia whitish, basal third dark grey.

Jem-Jem Forest, edge of forest, 9000 feet, October; 1 ex. A very distinct form.

GELECHIIDAE.

Polyhymno, sp.

1 worn ex., indeterminable, but near *cleodorella*, Wals., Debra Libanos, 8000 feet, January.

Stomopteryx ochrosema, sp. n.

♂. 10 mm. Head, thorax dark violet-fuscous, face white. Palpi white lined black. Fore-wings elongate-lanceolate, apex rather produced, acute; 6 and 7 out of 8, 9 out of 8 towards base; dark violet-fuscous; a moderate triangular pale ochreous spot on costa at ⅔, and small spot on tornus opposite almost connected with it: cilia grey, suffusedly mixed dark fuscous towards base. Hind-wings termen emarginate, apex long-produced, acute; grey; cilia light grey.

Addis Alam,* 8000 feet, October; 1 ex. Allied to *anthyllidella*; the stalking of vein 9 with 8 is not found habitually in any other species of the genus.

COSMOPTERYGIDAE.

Cosmopteryx epismaragda, sp. n.

♂. 11 mm. Head, thorax metallic-bronze. Palpi white lined black. Antennae blackish, a white band at about ¾. Abdomen blackish, two basal segments with dorsal pairs of coppery-orange spots. Fore-wings very narrow-lanceolate, apex caudate; blackish; a prismatic-whitish mark beneath costa at ⅕, and short streak beneath fold; a moderate orange median fascia with long posterior projection on costa, edged direct golden-metallic blackish-edged streaks suffused iridescent emerald-green on upper half, posterior terminated by costal projection; from beneath end of costal projection an emerald-golden streak to costa at ⅘, beneath this an orange streak in disc, and from margin of median fascia a fine golden line along termen to apex, extended through cilia: cilia otherwise dark fuscous. Hind-wings blackish; cilia dark fuscous.

Jem-Jem Forest, over 8000 feet, October; 1 ex. The basal markings of fore-wings are rubbed and may be imperfect, but the species is otherwise distinct.

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* About 20 miles West of Addis Ababa.

Ascalenia secretifera, sp. n.

♂♀. 12–13 mm. Head, thorax dark fuscous, faintly violet-tinged, sometimes minutely pale-speckled. Palpi blackish, minutely whitish-speckled, forming fine rings on terminal joints, tips of joints minutely whitish. Antennae rather dark grey. Fore-wings rather narrow, widest near base, apex long-pointed; dark bronzy-fuscous, some scattered minute whitish specks; plical and second discal stigmata moderate or somewhat large, black, slightly elongate, sometimes a blackish dash on fold between these: cilia light bronzy-greyish. Hind-wings grey; cilia light bronzy-greyish.

Mt. Chillálo, 9000 feet, November; 5 ex.

BLASTOBASIDAE.

Blastobasis eridryas, sp. n.

♂. 17–18 mm. Head light greyish-ochreous. Palpi slender, acute, ochreous-whitish, second joint suffused dark grey except tip, terminal joint slightly sprinkled dark grey. Antennae serrulate, shortly ciliated (½), but also with usually three very fine longer cilia (2½) at each joint, scape very stout, with minute apical projection and very slight notch at base of stalk. Thorax fuscous. Fore-wings elongate, rather narrow, costa gently arched, apex pointed, termen extremely oblique; brownish irrorated rather dark fuscous; stigmata indistinct, cloudy, dark fuscous, discal dot-like, plical forming a short dash slightly before first discal, an additional dot beneath second discal subconfluent with it: cilia light grey. Hind-wings grey; cilia light grey, slightly brownish-tinged towards base.

Mt. Chillálo, 8500 feet, in forest, November; 2 ex.

Blastobasis industria, Meyr.

Jem-Jem Forest, 9000 feet, October; 2 ex. Widely spread by man in East and South Africa.

OECOPHORIDAE.

Eucleodora chalybeella, Wals.

Jem-Jem Forest, edge of forest, 9000 feet, October, 1 ex., much damaged, without palpi, but apparently correctly identified.

CARPOSINIDAE.

Carposina candace, sp. n.

♀. 15 mm. Head white. Palpi white, second joint irrorated black except towards apex and upper edge. Thorax white, anterior edge grey. Fore-wings elongate, costa gently arched, apex obtuse-pointed, termen almost straight, oblique; white, a few scattered dark fuscous scales; a triangular blackish blotch occupying basal ⅙ of costa; six small blackish spots on costa from ¼ to near apex, some irregular grey and blackish irroration beneath these; a small blackish spot on dorsum near base; two blackish dots transversely placed in disc at ¼; an irregular grey cloud with some black scales in middle of disc, terminated by a small blackish spot; a slender grey fascia with some black scales from fifth costal spot to tornus, some scattered grey and black scales between this and preceding cloud; a fine irregular blackish terminal streak: cilia whitish-grey, on costa whitish barred grey. Hind-wings light grey; cilia whitish-grey.

Jem-Jem Forest, 9000 feet, October; 1 ex.

GLYPHIPTERYGIDAE.

Brenthia leucatoma, Meyr.

Wachacha Ravine, near Addis Ababa, 8000 feet, September; 1 ex. The hitherto unique type is from Durban, Natal.

Choreutis argyrastra, sp. n.

♀. 11–14 mm. Head, thorax dark fuscous, slightly speckled whitish. Palpi whitish mixed dark fuscous. Fore-wings rather elongate-triangular, costa gently arched, termen somewhat obliquely rounded; dark fuscous; a violet-silver-metallic subcostal streak from base to $\frac{1}{4}$; two obscure slender fasciae of grey-whitish irroration, forming small white spots on costa, first at $\frac{2}{5}$, nearly straight, followed on upper half by irregular silver-metallic irroration, second at $\frac{3}{4}$, excurved on upper $\frac{2}{3}$, preceded by some irregular silver-metallic marking beneath costa and scattered dots in disc, and followed on costa by a spot of fulvous suffusion; round apex and termen a submarginal series of about eight irregular partly confluent violet-silver-metallic dots; margin beyond this tinged fulvous; ground-colour round some of these metallic markings more blackish: cilia grey, darker on costa, on termen with fine white subbasal and subapical lines, and two dark grey bars blackish at base. Hind-wings dark grey; sometimes a slight grey-whitish transverse streak posteriorly in disc; cilia grey-whitish, two dark grey shades.

Mt. Zukwala, 9000 feet, October; 2 ex. Allied to *irradiata* and *hestiarcha.*

Ussara semicoronis, sp. n.

♂. 9 mm. Head, thorax dark fuscous. Palpi whitish. Fore-wings elongate, rather dilated, costa gently arched, termen oblique; 3 and 4 stalked; dark fuscous; six short slender white streaks from costa from $\frac{1}{3}$ to near apex, first three slightly oblique, others nearly direct; two yellow-whitish dorsal spots reaching fold, first at $\frac{1}{4}$, rather narrow, somewhat oblique, second at $\frac{2}{3}$, triangular; a silvery-metallic dot on end of cell, one before apex, and one or two or an erect mark at tornus: cilia whitish, a blackish basal line interrupted beneath apex, two blackish hooks from above apex and one from middle of termen. Hind-wings dark grey; cilia grey.

Jem-Jem Forest, 8000 feet, September; 2 ex. The examples (one especially) are somewhat abraded.

ELACHISTIDAE.

Elachista delocharis, sp. n.

♂. 7 mm. Head, thorax whitish-grey mixed blackish. Palpi whitish-grey, a black lateral line. Fore-wings lanceolate; black; a rather narrow somewhat irregular oblique white fascia before middle; a rather large subquadrate white spot on tornus and similar one on costa somewhat beyond it, nearly meeting: cilia grey, a black median line round apex. Hind-wings and cilia grey.

Jem-Jem Forest, edge of forest, 9000 feet, October; 1 ex.

HYPONOMEUTIDAE.

Hyponomeuta ocypora, sp. n.

♂. 22 mm. Head, palpi, thorax light grey, slightly mixed whitish. Fore-wings narrow-elongate, costa gently arched, apex pointed, termen extremely oblique; grey, with slight partial whitish tinge or reflections; a subcostal series of about six, and submedian series of about eight small black dots, dorsal edge from near base to tornus slenderly and irregularly whitish, with about eight to ten distinct irregular black dots just above edge; a small whitish costal spot towards apex partly in cilia: cilia pale grey, on costa dark grey, beneath apex a short blackish-grey median shade. Hind-wings pointed, pale slaty-grey; a small oval hyaline spot beneath cell at base; cilia light grey.

Jem-Jem Forest, nearly 9000 feet, October; 1 ex. Allied to *subplumbella*; the unusually narrow wings and whitish costal spot show affinity to *Swammerdamia.*

Telosphrantis, gen. n.

Head with appressed scales; ocelli posterior; tongue developed. Antennae $\frac{3}{4}$, ♂ with whorls of very long fine cilia, scape moderate, without pecten. Labial palpi moderately long, curved, ascending, with appressed scales, terminal joint shorter than second, slender, cylindrical, obtuse-pointed. Maxillary palpi rudimentary. Posterior tibiae with some rough hairs above on basal half. Fore-wings 2 from towards angle, 7 to termen, 7–10 approximated towards base, 11 from before middle. Hind-wings 1, subovate, cilia $\frac{1}{3}$; 3 and 4 connate, 5–7 nearly parallel.

Telosphrantis aethiopica, sp. n.

♂♀. 14–16 mm. Head, thorax dark fuscous. Antennal ciliations 6. Palpi light brownish-ochreous, terminal joint and upper part of second suffused dark fuscous. Fore-wings rather elongate, posteriorly dilated, costa gently arched, apex obtuse-pointed, termen nearly straight, rather oblique; dark bronzy-fuscous; extreme costal edge shortly pale ochreous before middle and at $\frac{2}{3}$: cilia dark fuscous. Hind-wings dark fuscous; cilia grey, a blackish-grey basal shade.

Mt. Chillálo, 9000 feet, in forest, November; 9 ex.

GRACILARIIDAE.

Acrocercops orianassa, sp. n.

♂. 8 mm. Head, thorax white, a small golden-brown spot on shoulder. Palpi smooth, white, terminal joint with dark fuscous median ring. Fore-wings rather narrow; golden-bronzy-brown; markings snow-white, black-edged; broad transverse fasciae narrowed towards costa at $\frac{1}{4}$ and beyond middle; a white dot on costa at $\frac{3}{4}$; a transverse white apical blotch: cilia grey, at apex suffused blackish basal and median bars. Hind-wings dark grey; cilia grey.

Mt. Zukwala, 9000 feet, October; 1 ex.

Acrocercops heteroloba, sp. n.

♂. 10–11 mm. Head, thorax white, shoulders grey. Palpi white, second joint with dark fuscous lateral line, anterior edge of terminal joint dark fuscous. Fore-wings very narrow, short-pointed; dark grey; a shining white streak occupying dorsal third to tornus, with oblong median and semioval tornal lobes above; a short oblique white strigula from costa above end of this; a transverse white apical blotch rather narrowed upwards and limited by a rather oblique blackish apical streak: cilia pale greyish, round apical area white with black apical dot at tips. Hind-wings and cilia grey.

Jem-Jem Forest, 8000–9000 feet, September; 2 ex.

Acrocercops horrens, sp. n.

♂. 12 mm. Head grey-whitish. Palpi white, second joint tufted with short rough hair-scales beneath, blackish except towards apex, terminal joint with blackish basal ring and median band. Thorax dark grey, tegulae suffusedly mixed whitish. Fore-wings narrow, short-pointed; dark fuscous; groups of irregular confluent white spots occupying most of wing about $\frac{1}{4}$ and middle; short oblique white streaks beneath costa and above dorsum beyond middle, an oblique white transverse line about $\frac{4}{5}$, a lunulate white transverse line from costa towards apex not reaching termen, these markings edged blackish but spaces between them more or less suffused pale ochreous especially towards apex, a small black apical spot: cilia ochreous-whitish, on costa and round apex white, blackish hooks above and beneath apex, and two grey shades beneath apex. Hind-wings dark grey; cilia grey.

Jem-Jem Forest, over 8000 feet, October; 1 ex.

Parectopa hexactis, sp. n.

♂♀. 10–11 mm. Head, thorax greyish, face tinged whitish. Palpi blackish, base whitish, second joint with short rough apical tuft beneath. Fore-wings very narrow; grey irrorated darker, margins irregularly spotted blackish, costal edge whitish between spots; three pairs of converging white strigulae from apical third of costa, first strigula oblique and continued to tornus, others reaching half across wing, apical area included within these except towards costa dull brownish-orange, a moderate black apical dot: cilia pale grey, basal half on termen within a curved blackish line dark grey, a straight projecting blackish apical hook. Hind-wings dark grey; cilia grey.

Jem-Jem Forest, 8000–9000 feet, October; 3 ex.

Gracilaria macropleura, sp. n.

♂. 12 mm. Head ochreous-whitish, collar tinged crimson-grey. Palpi slender, whitish, some grey irroration anteriorly. Thorax crimson-grey, tinged whitish anteriorly. Fore-wings very narrow, parallel-sided, short-pointed; dull light purple, with some indistinct grey strigulation; a moderate suffused whitish-yellowish costal band from about $\frac{1}{5}$ to $\frac{5}{6}$, occupying about $\frac{2}{5}$ of wing, a black dot just beneath costal edge before middle, some black specks on costal edge between this and base, and three beyond middle; a blackish dot on costa towards apex, and several minute dots on termen: cilia light grey, on costa whitish-yellowish, beneath apex with two fine blackish subapical lines. Hind-wings grey; cilia light grey.

Jem-Jem Forest, over 8000 feet, October; 1 ex. Allied to *prosticta*.

PLUTELLIDAE.

Lepocnemis metapelista, sp. n.

♂♀. 17–19 mm. Head, palpi, thorax white, variably infuscated, palpi sometimes dark fuscous, terminal joint as long as second. Fore-wings elongate, somewhat dilated, costa gently arched, more strongly posteriorly, apex pointed, termen sinuate, oblique; white, variably tinged or sprinkled or strigulated fuscous or with tips of scales almost wholly dark fuscous throughout, forming a close fine transverse striolation; an oblique rhomboidal dark fuscous blotch on middle of dorsum, sometimes obscure: cilia fuscous-whitish or fuscous, usually darker than wing, but not in one light example. Hind-wings and cilia varying from rather light to rather dark grey.

Jem-Jem Forest, 8000–9000 feet, October; 5 ex. Nearly approaching the typical species, *L. bascanopa* from the Transvaal, but larger and rather broader winged.

Plutella stichocentra, sp. n.

♂♀. 17–22 mm. Head brownish-ochreous or light ochreous, sometimes slightly mixed dark fuscous, edges white above eyes. Palpi dark fuscous, tuft of second joint short. Thorax greyish-ochreous more or less wholly suffused dark fuscous. Fore-wings elongate, costa gently arched, apex obtuse-pointed, termen very oblique; fuscous, variably irrorated or suffused dark fuscous, with several more or less distinctly developed longitudinal series of irregular black dots, dorsal area as far as fold sometimes light brownish or brownish-ochreous, its edge somewhat bisinuate and defined by dark fuscous suffusion above; two or three larger black dots on termen: cilia grey sprinkled dark fuscous. Hind-wings light grey; cilia whitish-grey, a grey subbasal shade.

Mt. Chillálo, 12,000–13,000 feet, beaten from a large tuft of a thorny alpine plant with everlasting flowers (subsequently identified at Kew as the Composite *Helichrysum citrispinum*) on a rock, in November; 9 ex. However, the larvae of eight species of *Plutella* are known, and these all feed on Cruciferae; the present species is of typical character, and it seems likely that the *Helichrysum* merely served for shelter in this desolate locality.

Plutella oxylopha, sp. n.

♂. 16 mm. Head whitish, somewhat mixed fuscous. Palpi blackish more or less mixed whitish, apical edge of second joint whitish, tuft very short. Antennae whitish, several ill-defined blackish-grey bands. Thorax blackish-grey slightly sprinkled whitish. Fore-wings elongate, costa gently arched, apex obtuse-pointed, termen very oblique; ashy-grey or dark grey sometimes mixed whitish, on costal half and dorsal edge with longitudinal series of black dots; dorsal area as far as fold forming a light grey streak partially edged white, with acute-triangular projections in middle and on extremity, edged between these and anteriorly with thick blackish suffusion; on posterior half of costa several small dark spots and costal edge whitish between these, or forming short transverse whitish marks: cilia whitish-grey, two blackish-grey shades. Hind-wings light bluish-grey; cilia whitish-grey, a greyer subbasal shade.

Mt. Chillálo and Mt. Zukwala, 9000 feet, October, November; 2 ex.

Plutella dryoxyla, sp. n.

♂. 20 mm. Head ochreous-whitish. Palpi whitish, second joint dark fuscous except base and apical edge, with moderate tuft, terminal joint slightly speckled fuscous. Antennae whitish, a grey band about middle and three towards apex. Thorax brownish, tegulae light brownish-ochreous. Fore-wings elongate, slightly dilated, costa gently arched, apex obtuse-pointed, termen oblique, slightly sinuate; brown, dorsal area as far as fold brownish-ochreous; scattered black dots indicating longitudinal series on costal half, and on dorsum; small blackish-grey spots on costa in and beyond middle, and on end of cell; a narrow blackish-grey terminal fascia hardly reaching tornus: cilia pale ochreous, on termen a black basal line and outer half suffused blackish-grey. Hind-wings light bluish-grey; cilia ochreous-whitish, a pale grey subbasal shade.

Mt. Chillálo, 9000 feet, November; 1 ex.

TINEIDAE.

Tinissa spaniastra, sp. n.

♂. 24 mm. Head whitish-ochreous, a few dark fuscous hairs. Palpi ochreous-whitish, second joint with two bands of dark fuscous suffusion, terminal joint with dark fuscous median band. Thorax whitish somewhat mixed fuscous, shoulders dark fuscous. Fore-wings elongate, rather dilated, costa gently arched, apex obtuse-pointed, termen faintly sinuate, oblique; all veins separate; rather dark purplish-fuscous, a few small whitish dots in longitudinal series; anterior half of costa blackish, marked seven small whitish direct strigulae; a white transverse spot on costa at $\frac{3}{5}$, and a small one at $\frac{3}{4}$; a rather small white spot on middle of dorsum; two white dots transversely placed on end of cell; a white tornal dot, and several small ones round apical and terminal margin: cilia fuscous, beyond a dark fuscous basal line a whitish subapical space and two or three whitish bars. Hind-wings light grey, some slight darker marbling posteriorly, especially on margins; cilia pale grey, a grey subbasal shade. Posterior tibiae dark grey, tips white.

Jem-Jem Forest, 8000 feet, October; 1 ex.

Philagrias, gen. n.

Head rough-haired; ocelli posterior; tongue obsolete. Antennae $\frac{5}{6}$, ♂ somewhat thick, simple, scape moderate, without pecten. Labial palpi rather long, curved, ascending, second joint with rough projecting scales beneath, almost tufted, terminal joint as long as second, slender, pointed. Maxillary palpi moderate, slender, filiform, folded. Posterior tibiae with tolerably appressed scales. Fore-wings 2 from towards angle, 3 from angle, 7 to termen, 10 from near end of cell, 11 from towards base. Hind-wings 1, elongate-ovate, cilia $\frac{1}{2}$; 2 from $\frac{2}{3}$, 3 from angle, 3–7 nearly parallel.

Perhaps in the line of transition from *Tinea* to *Tinissa*.

Philagrias zelotica, sp. n.

♂. 17 mm. Head, palpi, thorax grey mixed blackish, apex of tegulae whitish. Fore-wings elongate, rather dilated, costa gently arched, more strongly posteriorly, apex obtuse, termen obliquely rounded; pale greyish-ochreous irregularly irrorated dark fuscous, costal edge whitish irregularly marked blackish; some ill-defined irregular dark purplish-fuscous markings, especially blotches on fold about $\frac{1}{5}$ and before middle, a fascia from second blotch to costa beyond middle, and an irregular subterminal fascia from costa towards apex to tornus; two small white spots longitudinally placed in disc at $\frac{3}{4}$, and one on tornus: cilia whitish mixed dark fuscous. Hind-wings pale grey; cilia grey-whitish.

Jem-Jem Forest, 8000 feet, October; 1 ex. The specimen is in rather rubbed condition, but sufficiently recognisable.

Hylophygas, gen. n.

Head rough-haired; ocelli posterior; tongue absent. Antennae $\frac{4}{5}$ (?), joints closely set, ♂ shortly ciliated. Labial palpi moderately long, porrected, second joint tufted beneath with rough hair-scales, terminal joint shorter than second, moderate, pointed. Maxillary palpi rather short, slender, filiform, folded. Posterior tibiae with long loosely appressed hairs above. Fore-wings 2 from towards angle, 7 absent, 11 from towards base. Hind-wings 1, elongate-ovate, cilia $\frac{4}{5}$; 2 from $\frac{2}{3}$, 3 from angle, 3–7 nearly parallel.

An obscure member of the *Tinea* group, probably with affinity to the preceding.

Hylophygas convicta, sp. n.

♂. 17 mm. Head, palpi grey-whitish, slightly mixed blackish. Thorax pale greyish-ochreous sprinkled dark fuscous, shoulders dark fuscous. Fore-wings elongate, costa gently arched, apex obtuse-pointed, termen very obliquely rounded; ochreous-grey-whitish, irrorated fuscous and dark fuscous; extreme costal edge whitish; some dark fuscous suffusion towards base of costa; a small dark fuscous spot on fold at $\frac{1}{5}$; stigmata dark fuscous, discal forming small suffused spots, plical an irregular blotch rather beyond first discal; three or four small dark spots separated by pale spaces on costa posteriorly: cilia grey-whitish sprinkled fuscous and dark fuscous. Hind-wings pale whitish-grey; cilia whitish.

Jem-Jem Forest, 8000 feet, October; 1 ex.

Monopis triplacopa, sp. n.

♀. 17 mm. Head pale ochreous. Palpi dark fuscous, tip whitish. Thorax light brownish-ochreous, tegulae dark fuscous. Fore-wings elongate, costa gently arched, apex obtuse-pointed, termen very obliquely rounded; 3 and 4 stalked, 8 and 9 stalked, 11 from near end of cell; light brownish-ochreous, with faint fulvous tinge, extreme base suffused dark fuscous; discal impression whitish-hyaline, edged anteriorly and posteriorly by small blackish spots; a short narrow apical streak of fuscous suffusion: cilia light ochreous, a blackish apical bar. Hind-wings and cilia light grey.

Jem-Jem Forest 8000 feet, October; 1 ex.

Tinea glycinocoma, sp. n.

♂. 14 mm. Head pale yellow. Palpi dark fuscous, terminal joint whitish. Antennae dark grey, scape white. Thorax light grey suffusedly mixed dark fuscous. Fore-wings elongate, costa gently arched, apex obtuse, termen very obliquely rounded; ochreous-whitish, irregularly mixed and clouded fuscous, with scattered dark fuscous scales; base of costa and dorsum suffused blackish-fuscous; a suffused dark fuscous round blotch in disc at $\frac{1}{5}$, and one on costa at $\frac{1}{4}$; plical stigma forming a blackish-fuscous spot beneath middle; an irregular transverse dark fuscous blotch from costa beyond middle, terminated beneath by a blackish longitudinal streak representing second discal stigma: cilia grey-whitish mixed fuscous. Hind-wings 4 absent; grey; cilia grey.

Jem-Jem Forest, 8000 feet, October; 1 example. Resembles *despecta* in the unusual absence of a vein in hind-wings, but although belonging to the same group, it is not otherwise particularly allied to that species, from which it differs obviously in the yellow head.

Tinea luridula, sp. n.

♀. 13 mm. Head, palpi pale ochreous-orange. Antennae 1, grey. Thorax dark grey. Abdomen whitish-ochreous. Fore-wings elongate, costa moderately arched, apex pointed, termen extremely oblique; rather dark grey: cilia whitish-ochreous tinged orange towards base. Hind-wings pointed, grey; cilia ochreous-whitish.

Mt. Chillálo, moorland, 12,000–13,000 feet, November; 1 ex.

Tinea othello, Meyr.

Muger Valley, 5500 feet, December; 1 ex. Widely spread in Africa, and probably domestic.

Tinea nephelotorna, sp. n.

♂. 23 mm. Head orange. Palpi dark fuscous, apex of joints pale ochreous. Antennae grey. Thorax dark purplish-grey. Abdomen light grey. Fore-wings elongate, costa gently arched, apex tolerably pointed, termen obliquely rounded; light brassy-yellow; base of costa suffused dark fuscous; an undefined tornal spot of faint light grey suffusion: cilia light ochreous-yellow, a light greyish tornal bar. Hind-wings pale brassy-grey; cilia pale yellow.

Jem-Jem Forest, 8000 feet, September; 1 ex. Allied to *vastella.*

BIOLOGICAL OBSERVATIONS ON SOME NEOTROPICAL PARASITIC HYMENOPTERA

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[Read 2nd March, 1932.]

With Five Text-figures.

1. **Introduction.**

The following biological notes have accumulated during exploratory work entailing much travelling and are therefore by no means complete life-history studies. The extent of parasitism under different conditions and the economic bearing of the parasites in question have been dealt with, for the more important species, in another paper (1931, *Empire Marketing Board,* 42) and their classification in a third (1931, *Bull. Ent. Res.*, **22**: 267–277), where also several new species have been described.

2. **Parasites of sugar-cane moth-borers *Diatraea* spp.).**

Ipobracon grenadensis, Ashm. (Braconidae.)

This showy insect is by far the commonest of the several species of *Ipobracon* which attack *Diatraea* in the West Indies (Grenada and Trinidad) and British Guiana. The variation in size is tremendous—the males, for instance, measuring from 5 to 11 mm. in length. The egg is loosely attached to the outside of the host-larva within its burrow in the cane-stalk. The resulting larva feeds externally. In three cases I have seen the host-pupa, instead of the caterpillar, attacked; but in one of them the pupa was deformed as though it had succeeded in transforming after being stung by the ovipositing female parasite.

I. grenadensis has been reared from *Diatraea saccharalis* and *D. canella* in sugar-cane, from *Diatraea* spp. in *Paspalum virgatum* and from *D. impersonatella* in *Paspalum fasciculatum.*

Habits of the adult.—Adults of both sexes are strongly attracted to the flowers of the common weed-grass, *Paspalum virgatum*, in company with considerable numbers of the Longicorn beetle, *Oxymerus luteus*, Voet., which in flight, resembles them strongly, so that I have caught it by mistake. These *Paspalum* flowers form the centre of an active biocoenose. *Sarcophaga* spp. and other flies frequent them; and nearly every flower-head has one specimen of the Reduviid, *Zelus rufigeniculatus*, Hav., with sticky legs. I have seen it sucking the juices of a small *Conocephalus* nymph, and also with its beak inserted into a floret, as though feeding there also. Spiders, especially Thomisids, seek their prey on the flowers, and one of the latter family had seized a small Clubionid spider. The most conspicuous and abundant guest is, however, *Ipobracon grenadensis,* which is seen also occasionally on the flowers of two other grasses, *Paspalum millegrana* and *Panicum grande.*

They visit, too, but not in such numbers as on *Paspalum virgatum,* the extra-floral nectaries of the shrub, *Cordia interrupta,* especially in late afternoon or evening. But even more attractive than any of these are the open, juicy, saucer-like, dark-coloured nectaries at the base of the flower-stalks of the pubescent, mauve-flowered Leguminous cover-crop plant, *Pueraria javanica*, grown at the Imperial College of Tropical Agriculture. Here *Polistes canadensis*, a small *Polybia* and large numbers of the Chalcidid, *Spilochalcis femorata*, F., are accompanied by no fewer than five species of *Ipobracon*, including the present one and a cacao-beetle parasite (*I. depressi*, Vier.), to be dealt with later on.

Ipobracon grenadensis, like all the other species with which I am familiar in life, is a slow flyer, with a habit of exuding, when roughly handled, a secretion which slightly stains the fingers and carries a peculiar and unpleasant odour. Some of the larger species of the genus sting very painfully, and all are conspicuously coloured in yellows or reds and black. They thus offer typical examples of warning coloration.

I have followed the female *Ipobracon* at work among cane and on water-grasses (*Paspalum repens*), but in both cases the difficulties of the environment prevented a close view of the process of oviposition. A female observed in a cane-field flew straight to a " dead heart "—a cane-shoot bored and killed by *Diatraea*—alighting on the stem about a foot from the ground. Thence it crawled slowly downward. But the inspection was brief, and it flew once more, to alight on the same stem nearer the ground. It stayed there less than a minute, and then continued its flight, down the cane-row and across a ditch. There it alighted at once on another dead heart, on the stem itself; but stayed only a moment and took flight whither I was unable to follow. I cut out both dead hearts and found them long abandoned by the borer.

Females kept in captivity lived only a few days on a diet of split sugar-cane alone, but one survived as long as twenty-four days when supplied with raisins, which furnished it both food and moisture in a highly convenient form. Two females dissected in Demerara contained 5 and 8 almost fully formed eggs respectively, and little sign of any others.

Effect on the host larva.—The host larva is apparently always paralysed, to some extent, by stinging at the time of oviposition, and this paralysis endures, not only until the egg, which is attached loosely to the outside of the caterpillar's body, has hatched, but also until the host is consumed by the resulting parasite larva. The extent of paralysis varies; always the legs, both thoracic and abdominal, are incapacitated, but sometimes only they. Occasionally the fore-part of the body only—save the legs—is movable. At other times a host-larva, with legs alone paralysed, can move its mouth-parts and squirm violently, curve in a bow, and roll over and over, though unable to progress. I have seen also complete paralysis, even including the mouth-parts, which are rarely affected. A curious case was that of a full-grown *Diatraea canella* caterpillar, with a parasite larva, 6 m. long, lying alongside the posterior third of the body. The mouth-parts, some anterior segments and the anal segment were movable and active, but the legs and the several segments on which the parasite lay were extended and paralysed. It would appear here as though there were two stings, one to paralyse the thoracic legs and the other to incapacitate the abdominal claspers. Paralysed larvae are often able to defaecate, and the heart-beat remains normal. There is none of that general flaccidity so characteristic of *Plodia* caterpillars stung by *Microbracon*, though this may intervene later, as the parasite grows larger and perhaps as a result of its increased feeding. Even then the heart continues to beat vigorously—practically until the parasite begins to finish off its host in a predatory manner.

A full-grown caterpillar of *Diatraea canella* bearing a newly-hatched *Ipobracon* larva, was kept, without the parasite, to study survival under paralysis. The paralysis in this case was semi-complete, including of course all the legs and to a less extent the whole fore-part of the body, which could be merely raised or depressed, whereas the abdominal segments could squirm vigorously. Heart-beat was apparently normal. On the seventh day the caterpillar seemed quite unchanged, the heart-beat normal, and defaecation had occurred twice. On the ninth day it was appreciably shortened, as though about to pupate, and had spun a number of irregular threads of silk.* On the nineteenth day it was dead and dried up.

On the subject of paralysis I might here mention a curious cataleptic condition which occasionally occurs in *Diatraea* larvae. The first case which came to my notice was that of a full-grown larva of *Diatraea saccharalis*, cut out of sugar-cane, quite flaccid and soft, looking dead but fresh. Unfortunately no observations were made on heart-beat. It was placed in a separate tube in my pocket, where it stayed one hour and three-quarters, and was then found to be lively and quite normal. It was dissected and found free from parasites.

In the second case a *Diatraea busckella* larva, collected on the 11th December, to rear, was found on the 11th February to have emerged from its boring, and was lying " dead " though not flaccid nor discoloured, but fully extended. The next day it was active and apparently healthy, but on the 24th it was again immobile and stiff, but not hard, and I could detect no heart-beat. It continued in this condition without further recovery, and by the 2nd March it was dead and rotten.

Habits of larva.—The larva of *Ipobracon grenadensis* is of the typical, external-feeding Braconid form but with conspicuous and prominent antennae when newly hatched. I have only partial data on the length of the feeding-period. At the end of this, ordinarily the larva constructs in the burrow of its host, a tough, smooth, close-textured, papery cocoon, of a biscuit-colour, varying somewhat in form according to exigencies of space. The typical shape is that of a slightly compressed cylinder (*i.e.* broadly elliptical in cross-section), very truncate at the roughened and thickened ends, which show a very slightly projecting selvage, as it were. The adult usually cuts an irregular hole in the side close to one end, not so often in the thickened end itself. A typical cocoon measures 18 mm. long by 6 mm. in greatest width.

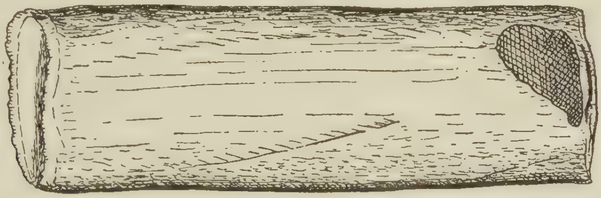

FIG. 1.—*Ipobracon grenadensis*, Ashm. Cocoon after emergence of imago.

Although this cocoon is entirely independent of and easily separable from the walls of the burrow, yet the latter are apparently necessary in its construction—perhaps for scaffolding. When larvae were confined in tubes 35 by 15 mm. they spun, in each case, a large mass of brownish silk from the cork to the end of the tube, over the full width of the latter, making an irregular but substantial flattish hammock on which they pupated entirely naked. Larvae placed, even when very young, in small gelatin capsules with their host caterpillar, ordinarily came to maturity without difficulty, the cocoon being spun of a normal shape, and the adult cutting its way, first out of the cocoon and then out of the capsule.

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* Before pupation *Diatraea* larvae normally spin a slight network across the emergence hole of the burrow. In this case the larva was lying on a flat surface.

Ipobracon puberuloides, Myers. (BRACONIDAE.)

This species has been reared from *Diatraea saccharalis* and *D. canella* in sugar-cane (British Guiana); from *D. impersonatella* in the grass, *Paspalum fasciculatum* (Trinidad); from *D. saccharalis* in *Paspalum repens* (British Guiana) and in *P. fasciculatum* (Venezuela).

The adult has been observed on *Paspalum conjugatum* in virgin lowland rain-forest in Trinidad, on floating beds of the grass, *Hymenachne amplexicaulis* in British Guiana, and on *Panicum grande* infested by *Diatraea saccharalis* in Venezuela.

The cocoon, of which a typical one measures 12 by 3·5 mm., is scarcely to be distinguished from that of *I. dolens* (described below), but I have no series adequate for comparison. It seems to be, however, of appreciably thinner texture, more like that of *Microdus stigmaterus* (also described later).

Ipobracon dolens, Cameron. (BRACONIDAE.)

This is the commonest parasite of *Diatraea saccharalis* in the water-grass, *Paspalum repens*, in British Guiana. It has been reared also from *Diatraea* spp. in razor-grass (*Paspalum virgatum*) and in sugar-cane (very rarely), and from *D. saccharalis* in rice (*Oryza sativa*). It occurs in Trinidad, British Guiana and Venezuela. It feeds occasionally on the flowers of *Paspalum virgatum* and may be seen abundantly on the floating beds of *P. repens*.

One larva, which was later reared, pupated after eating barely half its 15 mm. host-larva (*D. saccharalis*), the remains of which were bunched in the tunnel near one end of the parasite cocoon.

There is evidence that the stinging of the host-caterpillar at oviposition is more severe than in the case of *I. grenadensis*. Thus, of seven larvae of *D. saccharalis* found parasitised in *Paspalum repens*, chiefly by this species, in four, on which the parasite larva was evidently newly-hatched, and not over two mm. long (in at least one case, not yet attached to feed) the host, though thoroughly limp and flaccid, could move the mouth-parts and head a little, and the heart was beating. In the other three, the parasite was over two and under 4 mm. long and no heart-beat nor head-movement was perceptible in the host. The next morning—seventeen hours later—all the parasites had fed, and all except one were now over 2 mm. in length. In the case of this one only was the heart-beat of the host perceptible, and twenty-four hours afterwards even this had ceased.

There was one instance, however, in which the host-caterpillar had evidently barely survived the initial stinging. The parasite larva was just hatched, yet the host was extremely flaccid and apparently dead, but I could just detect a very feeble and slow heart-beat.

The cocoon of *Ipobracon dolens* is closely similar to that of *I. grenadensis*, but tends to be less regular in shape, perhaps due to exigencies of space in a very much smaller host-plant (*Paspalum repens*). It is generally paler in colour and smaller, a typical specimen measuring 10 by 3 mm.

Ipobracon pennipes, Myers. (BRACONIDAE.)

This species has been reared from *Diatraea* sp. in sugar-cane and in *Paspalum virgatum*, but is very rare. Both my specimens came from Berbice, British Guiana.

The cocoon is pale brownish, shining, truncate at both ends, and almost exactly circular in cross-section. Size, 10 by 2·5 mm.

Ipobracon aquaticus, Myers. (BRACONIDAE.)

This tiny species has been reared only from *Diatraea saccharalis* in water-grass, *Paspalum repens*, Berbice, British Guiana. It is rare.

The cocoon is of the same type as the preceding, but pure white and only 5 by 1·5 mm.

Associated with *Diatraea* spp. in the stems of razor-grass, *Paspalum virgatum* in British Guiana are numerous larvae of another moth, *Chilo calamistis*, Hamps., which are normally not parasitised by the Braconids which attack *Diatraea.* Two *Chilo* larvae, however, out of many hundreds examined, were parasitised by a tiny *Ipobracon* sp. which I failed to rear, and which may, or may not, have been one of the smaller species discussed above.

Apanteles diatraeae, Mues. (BRACONIDAE.)

This species has been reared from *Diatraea saccharalis* in sugar-cane in Cuba; and from *Diatraea* spp. in sugar-came in Trinidad; but is much more abundant as a parasite of *Diatraea lineolata* in maize.

As many as 81 larvae may emerge from a single host-caterpillar. The largest number I have obtained from one host by dissection is 144 (*D. saccharalis*). The larva is a typical *Apanteles.*

The cocoons are white, usually slightly stained, tough, comparatively smooth, tightly compacted into a single mass in the burrow of the host. A typical cocoon measures 3·7 by 1·8 mm.

Microdus stigmaterus, Cress. (BRACONIDAE.)

This is by far the commonest of the three described species of *Microdus* parasitising *Diatraea* caterpillars in British Guiana and throughout the West Indies, save the drier islands like Antigua and Barbados. It has been reared from *Diatraea saccharalis* in sugar-cane (British Guiana, Cuba, Jamaica, St. Kitts, Montserrat), in *Hymenachne amplexicaulis* (British Guiana, Haiti), in rice (*Oryza sativa*) (British Guiana, Haiti), in *Paspalum millegrana* (Cuba), in *P. virgatum* (St. Lucia) from *D. canella* in sugar-cane (British Guiana), and from *D. lineolata* in maize (St. Lucia). Larvae almost certainly of this species have been dissected from caterpillars of *Diatraea saccharalis* in sugar-cane (Venezuela, Trinidad), in *Coix lacryma-jobi* and *Paspalum virgatum* (St. Lucia), in *Paspalum fasciculatum* (Venezuela), and in *Paspalum repens* (British Guiana); from *Diatraea impersonatella* in *Paspalum virgatum* (Trinidad, British Guiana), in *Paspalum millegrana* (British Guiana); from *Diatraea canella* in *P. virgatum* (British Guiana, Trinidad), in *P. millegrana* (British Guiana), and in rice (British Guiana). An unidentified *Microdus* larva, which may be this species, was dissected very rarely from caterpillars of *Chilo calamistis*, Hamps., in *Paspalum millegrana* (British Guiana).

The adults, like those of *Ipobracon grenadensis*, are bright red and slow flyers. They have been seen on the leaves of *Cordia interrupta*, but never in such numbers nor so regularly as *Ipobracon*.

The eggs of both this and the two following species are inserted within the body of the host, and the resulting larva feeds internally. Towards the end of this feeding period the host-caterpillar appears flaccid and apparently dead. Oviposition occurs in half to full-grown caterpillars. Two young larvae may occur in one host, but I have never seen more than one adult result.

The larva, especially in the younger instars, is of a most peculiar and unmistakable form. Not only is there a conspicuous "tail" appendage, but ventrally there is a row of large mamma-like projections furnished with nipple-like extremities. When the young larva is dissected out of the host it is very active, bending double, either dorsally or ventrally.

The cocoon is ordinarily constructed within the burrow of the host, after this has made an opening to the exterior. In several cases, however, I have found it attached to the outside of the stem, merely covered by a portion of the leaf-sheath.

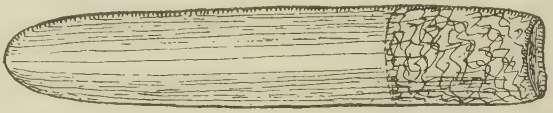

Fig. 2.—*Microdus stigmaterus*, Cress. Cocoon after emergence of imago.

It is whitish transparent, with the appearance and texture of tissue-paper. In comparison with that of *Ipobracon grenadensis*, which it resembles in size, it is easily torn. The shape is almost cylindrical, tapering a very little towards each end. The posterior end is round; the anterior end rather truncate, with the anterior 3 mm. or more filled with fluffy white silk threads forming a kind of baffle chamber. A cocoon measures 17 by 3·5 mm.

Microdus sacchari, Myers. (Braconidae.)

This Braconid, very similar in appearance to the last, has been reared from *Diatraea* spp. in sugar-cane (Trinidad) and *Paspalum virgatum* (British Guiana), and from *D. saccharalis* in *Paspalum repens* (British Guiana–Venezuela border). Trinidad is apparently the northern limit of its range.

Neither the larva nor the cocoon has yet been distinguished from those of the preceding species.

Microdus parvifasciatus, Cam. (Braconidae.)

Although this smaller, dark species was originally described from British Guiana, I have encountered it only in Trinidad. Once it was reared from *Diatraea impersonatella* in *Paspalum virgatum*, and once from *Diatraea* spp., chiefly *D. impersonatella* (the species not being separated) in sugar-cane.

Spilocryptus diatraeae, Myers. (Ichneumonidae.)

The parasite which I have described under this name is rare. It has been reared from *Diatraea* spp. in sugar-cane and, more frequently, in *Paspalum virgatum* (British Guiana). Very little is known of its habits, and I have never seen the adult in the field.

The cocoon is dark brownish-olivaceous, very tough, irregularly cylindrical, more or less truncate at both ends. A typical example measures 17 by 4 mm.

It resembles considerably that of *Ipobracon grenadensis*, but is normally of darker colour, coarser texture and rougher surface, on which individual threads are often overlaid.

Perisierola bogotensis, Kieff. (BETHYLIDAE.)

This minute wasp was found parasitising small larvae of *Diatraea saccharalis* in the stems of a water-grass, *Paspalum repens*, in British Guiana. Kieffer (1908, *Marcellia*, **7**: 140) records it from a Lepidopterous caterpillar forming elongate stem galls on a species of *Eupatorium* (Compositae) in Colombia. In one gall were found five cocoons lying together, 5 mm. long and 2·5 mm. wide, of yellowish-white silk. Only females emerged.

British Guiana cocoons built in a gelatin capsule in the laboratory are of very light texture, transparent, filmy, and measure 4·5 by 1·5 mm., which is considerably smaller than the Colombian examples, but still extremely large for the size of the insect.

I found the species on one occasion only. The host-caterpillar was 6 mm. long, paralysed, but healthy-looking and sound. I was unable to observe any heart-beat. The three smooth, transparent ovoid larvae were fastened on the dorsum.

Other Hymenopterous parasites of Diatraea.

Some four further species of *Ipobracon*, discovered within the last year by Mr. Box and by myself, are apparently new, and must await description. The same applies to another species of *Microdus*.

The pupal parasites of the genus *Spilochalcis* need systematic revision, for there is at least one new species, discovered by Mr. Cleare. The form parasitising *Diatraea* in sugar-cane is apparently always *Spilochalcis dux*, Walk. (*Heptasmicra curvilineata*, Cam.). Only one adult emerges from a single host. The percentage of parasitism during the present study was 1·1 per cent. in Demerara, 0·7 per cent. in Berbice, while in Trinidad it does not seem to occur, though at least one other species has been reared, the percentage of parasitism being negligible. True *S. dux* was reared from *Diatraea saccharalis* in *Panicum grande*, on the north coast of Venezuela (Ocumare de la Costa).

3. **Parasites of the cacao beetle (*Stirastoma depressum*).**

The parasite complex, of which this beetle is the centre, has proved much more extensive than was originally supposed. It comprises no fewer than five species of *Ipobracon*, two of which are undetermined and probably new, all external parasitoids, and one internal parasitoid, the Eulophid, *Pseudomphale steirastomae*, Gir.

The larvae of the various species of *Ipobracon* have not yet been differentiated.

Ipobracon peronatus, Cam., I have not actually reared from *Stirastoma*, but it has been captured in cacao plantations and in second-growth rain-forest near examples of the tree, *Pachira insignis*, which is an important host of the beetle.

I. steirastomae, Vier., has been reared from *Stirastoma* in cacao branches, and has likewise been captured flying in cacao plantations.

I. depressi, Vier., was reared from *Stirastoma* in both cacao, and wild okra (*Malachra alceifolia*), while adults were captured flying about both these plants, and frequenting the extra-floral nectaries of a cover-crop plant, *Pueraria javanica.*

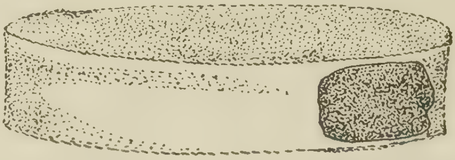

Fig. 3.—*Ipobracon depressi,* Vier. Cocoon after emergence of imago.

The cocoon of this species is of very characteristic and curious form. Viewed in plan it is long elliptical, narrowed almost to a blunt point. The dorsal and ventral surfaces are flat and similar, while the sides are exactly perpendicular, meeting the top and bottom in a sharp right angle, the pointed ends appearing as blunt keels. A typical specimen measures 17 by 6 by 3 mm. The material is a smooth, extremely tough and close-textured, buff-coloured silk. The cocoon is fastened to the wall of the host-gallery.

A cocoon which still contained a larva was opened along one whole side for examination, and then placed for rearing in a gelatin capsule. The larva spun up the opening completely, fastening the cocoon firmly to the side of the capsule.

The following observations refer to a fourth and as yet unnamed *Ipobracon* (no. 1086) reared from *Stirastoma depressum* in *Malachra alceifolia.* The host-grub, during the earlier stages of parasitism, seems in excellent condition and plump, though not so turgid as usual. The heart-beat is slow. There is definite paralysis, to a certain extent. In the case examined most closely the posterior half or third of the grub was freely movable—able to squirm, contract or turn from side to side. The anterior half, however, was quite immobile, and the mouth-parts completely paralysed. At this time the parasite larva was 5 mm. long. Three days later it was 8 mm. long and proportionally very much stouter.

The internally parasitic larvae which were identified as those of *Pseudomphale steirastomae* were encountered in considerable numbers—12 to 44—in a single host-grub. They were not found in the material from wild okra (*Malachra*). Parasitised grubs were small—usually from 18 to 22 mm. long.

4. Parasites of the chayote caterpillar (*Diaphania hyalinata*).

An old and tangled mass of vines of the chayote, chocho or christophine (*Sechium edule*) in the garden of the Atkins Harvard Biological Station near Cienfuegos, Cuba, gave opportunity, during a travelling delay, to investigate somewhat cursorily another interesting and extensive parasite complex. Since the Tachinids have not yet been determined, only the Hymenoptera are considered here.

My attention was first drawn to the vine, in late September, by the hundreds of Ichneumonids and Chalcidids which crowded round it. Of the former all proved to be males of *Polycyrtus lituratus,* Brullé, while the Chalcidids were two species of *Spilochalcis,* chiefly females. The vine itself was heavily infested with the "pickle worm" (*Diaphania hyalinata*).

To gain a rapid notion of the nature and extent of parasitism, I examined 100 *Diaphania* cocoons, from dead leaves, dissected 100 larvae, and began a bulk culture to obtain adult parasites.

The vast accumulations of dead leaves in the top of the arbour, where the larvae were pupating, sheltered numerous other insects and spiders (but no scorpions), including cockroaches of several kinds (not house species), a Pentatomid, a small slender Reduviid, numerous crickets, a red nymphal Anthocorid and some small beetles.

The 100 cocoons yielded the following results :—

Diaphania pupae, emerged as moth	30
,, ,, alive, unparasitised	9
,, ,, dead, not parasitised	2
,, ,, parasitised by *Pimpla*	2
Diaphania prepupae, parasitised by *Polycyrtus*	5
,, ,, healthy	1
,, ,, parasitised by undetermined endoparasitic Ichneumonid	1
Diaphania larvae, dead and dried-up, in cocoon	7
,, ,, killed (?) by white, fluffy fungus	3
,, ,, containing Tachinid puparia	3
,, ,, ,, *Polycyrtus* cocoons	28
,, ,, ,, banded cocoons of undetermined Ichneumonid	8
,, ,, ,, larva of *Polycyrtus*	1
	100

To sum up, 48 *Diaphania* had been parasitised by insects, namely 34 by *Polycyrtus lituratus*, 2 by *Pimpla marginella*, 8 by an unidentified Ichneumonid, 3 by an undetermined Tachinid, and 1 by an Ichneumonid which may have been the *Pimpla* above mentioned. In addition there were 12 solitary *Apanteles* cocoons, the complicated host-relations of which are dealt with later, and certain instances of hyperparasitism which will also be detailed below. Three per cent. were covered with a white fungus, which had perhaps killed them, though prepupae killed by ovipositing *Polycyrtus* were similarly affected when the egg was removed.

The dissection of 100 larvae, of all sizes, but mostly well grown, yielded the following results :—

Healthy	95
Parasitised by an undetermined green endoparasitic Ichneumonid larva	1
Parasitised by a solitary *Apanteles*.	1
Parasitised by green muscardine fungus (*Metarrhizium anisopliae*)	3
	100

It is significant how suddenly the extent of parasitism increases once the larva has constructed its cocoon.

In addition to the gross examinations above, a number of parasitised larvae were kept under observation, and the results, with those of the bulk culture, are now recorded under the individual species concerned.

Polycyrtus lituratus, Brullé. (Ichneumonidae.)

Habits of the adult.—In September, as the above records show, this was by far the commonest parasite of *Diaphania.* It is a widespread species in Cuba and Haiti, often taken in second-growth and open forest, miles from any cultivation.

The males were conspicuous, in large numbers, with dancing flight, round the infested chayote vine. The females, either not yet emerged in bulk, or hidden among the masses of dead leaves, in search of host cocoons, were much less often observed. From the bulk culture the sexes were reared in approximately equal numbers.

The host is almost always attacked as a prepupa, though in at least one case the fully-formed and hardened pupa was the victim.

The effect of stinging, by the female at oviposition, is somewhat obscured by the usual immobility of the prepupa, which varies with the development of the latter. There is, however, good evidence that the prepupa is actually killed, since in some cases it was already black and decomposing at the extremities while still bearing only an egg. One prepupa, with a 3·5 mm. *Polycyrtus* larva on its side, showed a small, blackened, bruise-like area near the posterior end. The heart was easily seen, throughout its length, and no beat was perceptible under the binocular. This was confirmed in two other cases, one still carrying only an egg. In the latter instance the egg was removed, and the very fresh and green-looking host-prepupa kept under observation. Eighteen hours later it was very soft but still green, though a blackish exudation appeared at the anus. In another twenty-four hours it appeared unaltered, but five days after removal of the egg, it was blackish, decomposed and deliquescent, half covered with a growth of white fuzzy fungus. This raises the question whether the larvae found infested with this fungus are ones which have been killed by *Polycyrtus*, but on which the parasite egg has not developed.

The eggs and larvae of Polycyrtus.

The egg is long, slender, even-ended, nearly parallel-sided, tapering very gradually to the roundly-pointed ends; a typical example measures 2·15 by 0·39 mm. The surface is smooth and transparent. It is placed usually on the side of the prepupa.

An egg found on the 28th September hatched about eighteen hours afterwards. The posterior end of the young larva was still fastened in the mouth of the empty egg-shell, whence the larva projected at right angles, with its head touching one of the strands of the host-cocoon. The body segmentation was conspicuous and the colour at this stage, before feeding, a translucent whitish. The head seemed proportionately huge, shining, in dorsal view trapezoidal, wider than any part of the body. The antennal processes were conspicuous, bearing long, conical antennae directed straight forward. The brown, long, sickle-shaped mandibles were working vigorously. When next observed, in an hour, it was lying flat on the surface of the host. For some reason the host eventually decayed and the parasite perished.

Another egg, found on the same date, also hatched next day. This young larva likewise left the empty eggshell. On the morning of the third day it measured 6 mm. and the host was blackened and decomposed along half its length. Twenty-seven hours later the parasite was 12 mm. long and the host practically devoured. Three days later the cocoon seemed complete, and on the 13th day after hatching of the egg, the adult *Polycyrtus*, a female, emerged. From other observations this seems to be a typical life cycle.

A hundred per cent. or more increase in length during the last twenty-four to twenty-six hours of larval feeding was observed several times, and is apparently regular. The young larva soon becomes distinctly greenish, but full-fed larvae often turn nearly white again.

In one case a Tachinid larva emerged from the host-prepupa, on which a

Polycyrtus grub had nearly finished feeding. Both the Ichneumonid and the Tachinid developed normally to adults. Several times a Tachinid puparium was found alongside a *Polycyrtus* cocoon. Occasionally, also, an *Apanteles* larva emerged from prepupae parasitised by *Polycyrtus* and constructed its cocoon near that of the Ichneumonid.

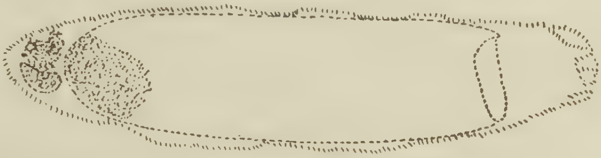

FIG. 4.—*Polycyrtus lituratus*, Brullé. Cocoon after emergence of imago, lying within cocoon of host, with remains of latter at end.

The cocoon of *Polycyrtus lituratus* is smooth, pure glistening white, close-textured, opaque, with a slightly wavy surface, cylindrical with rounded ends, and measuring 15 by 4 mm. It occupies the whole diameter of the diaphanous host-cocoon, without reaching either end, one of which is occupied by the remains of the host. When a pupa has been attacked, the stiff, cleaned shell is incorporated in the wall of the Ichneumonid cocoon. Emergence is by a ragged hole made by eating out the whole of the anterior end.

Pimpla marginella, Brullé. (ICHNEUMONIDAE.)

In addition to the rearing records, examples of this species were taken in semi-cultivated mountain districts in both Cuba (San Blas) and Haiti (Kenscoff).

It is a parasite of *Diaphania* pupae, in which the solitary parasite larva, when full-fed, occupies nearly all the space, and pupates with no cocoon. From the completion of feeding to the emergence of the adult is about five days.

In two cases, in spite of the size of the *Pimpla* pupa it was accompanied inside the host-chrysalis by a pupa of *Spilochalcis* sp. (not reared) nearly ready to emerge, *i.e.* at a stage more advanced than the Ichneumonid.

Neotheronia bicincta, Cress. (ICHNEUMONIDAE.)

Two males were reared from the bulk culture, evidently from pupae or prepupae of *Diaphania.*

Unidentified Ichneumonid.

This species, of which only empty cocoons were found, was thus never reared. It apparently attacks *Diaphania* pupae or prepupae somewhat earlier in the season. The cocoons are sufficiently distinctive—smaller than those of *Polycyrtus* but of similar shape, constructed of very tough, brownish or amber-coloured, translucent silk, smooth, but apparently overlaid with a thin layer of coarser whitish fibres and the whole invested in the diaphanous host cocoon. A typical example measures 8 mm. in length. But the most striking feature is the presence of two sharply-defined contiguous bands round the middle, one dark brown and the other pure white. Emergence takes place through an irregular hole at the anterior end.

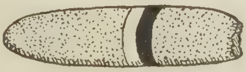

FIG. 5.—Cocoon of undetermined Ichneumonid, parasitic on *Diaphania*, after emergence of imago.

Apanteles sp. (Braconidae.)

A solitary *Apanteles* was a common parasite of younger *Diaphania* larvae. Owing to hyperparasitism, it was unfortunately never reared. A larva dissected from an 8 mm. caterpillar was of the usual *Apanteles* form, with a large, rounded bilobed caudal vesicle, the surface of which was marked with curious roughened, squarish patches very like those on a scabby potato.

The cocoon is pure white, 3·4 mm. long, and is fastened to the leaf somewhere in the vicinity of the host but usually outside its cocoon. Emergence is effected by a small circular cap at the anterior end, which is left hanging like a lid.

In several cases the *Apanteles* cocoon was adjacent to one of *Polycyrtus lituratus* or of the undetermined Ichneumonid, under circumstances which showed that the *Apanteles* larva had emerged either from the other parasite or from the same host. Cocoons of both Ichneumonids sometimes showed small, irregular emergence holes near one end, and an *Apanteles* cocoon lying only a few millimetres away; so that occasional hyperparasitism is at least probable.

All *Apanteles* cocoons kept for rearing produced a hyperparasitic Eulophid, *Tetrastichus* sp., 3 to 5 emerging by one small circular hole in the side of each cocoon, near one end.

Spilochalcis fulvescens, Ashm. (Chalcididae.)

This was reared, not from *Diaphania* itself, as reported in 1931, *Bull. Ent. Res.*, **22**: 275, but from the puparium of the undetermined Tachinid which attacks the pupae of this moth.

The *Spilochalcis* dissected from *Diaphania* pupae was probably *S. femorata*, F., which was taken in enormous numbers flying about the chayote vine. It is attracted in swarms to the extra-floral nectaries of *Pueraria* in Trinidad.

5. Parasites of the papaya and cassava sphinx caterpillars.

In Cuba and Haiti the cassava sphinx (*Dilophonota ello*, L.) and the papaya sphinx (*D. alope*, Dr.) are very frequently attacked by the Braconid, *Apanteles flaviventris*, Cress., and by a number of hyperparasites.

These gigantic caterpillars support an astonishing number of *Apanteles* larvae. Cardin records 627 from a cassava sphinx (1911, *Estac. exp. agron., Santiago de las Vegas*, Bol. **20**, 28 + [2] pp., 8 pls.), and I have reared 463 from the papaya sphinx in Haiti.

The *Apanteles* cocoons are agglomerated in a huge, white fluffy mass, arched over the remains of the host, which usually slip out, and leave on the leaf an oval arched structure like stiff cotton wool, 5 cm. long and 3 wide, by 2 high. This mass is so conspicuous that it has received a popular name, " algodón de la yuca " or cassava cotton. Cardin has published an excellent account of the method of weaving these cocoons.

Apanteles flaviventris is very frequently attacked by hyperparasites, the relations of which *inter se* have not been elucidated. Thus, from a papaya cocoon-mass collected at Soledad, Cuba (17th August), emerged 93 hypers. of the species *Eurytoma walshi*, How. (Eurytomidae), and *Horismenus apantelivorus*, Crawf. (Eulophidae), and no *Apanteles*. Similarly, a cassava cocoon-mass collected at Baraguá, Cuba (17th October), yielded, up to the 9th of November, only 1 *Apanteles*, but an immense number of *Eurytoma walshi*, *Horismenus apantelivorus*, *Elasmus punctulatus*, How., and *E. maculatus*, How. (Elasmidae). On the other hand, a mass from papaya in Haiti (21st November) produced 463 *Apanteles* and only one hyperparasite—a male *Elasmus punctulatus*.

It is interesting to note that the cassava hawk-moth seems to have no parasites in Barbados (1914, Anon., *Agric. News*, **14**), where it is sometimes a severe pest, causing, in one instance, complete defoliation over 12 acres.

6. Miscellaneous records.

The systematic paper already mentioned (1931, *Bull. Ent. Res.*, **22**: 267–277) includes a list of bare host-records. These are not repeated here, unless further biological details are available. A close study has been made of an extensive parasite complex on the mahogany-tip borer (*Hypsipyla* spp.), but most of the parasites have not been determined, and therefore cannot yet be reported on. A few are included in the following notes, which are arranged in systematic order.

ICHNEUMONIDAE.

Bristowe and others have commented on the scarcity of Ichneumonids in the Tropics. In the Trinidad and Guiana forest they are certainly much less often encountered in general collecting than in such temperate regions as Western Europe, Eastern North America and New Zealand. The facies of the Guiana and Trinidad Ichneumonid fauna is marked by a preponderance of black and yellow forms with clear wings and often white-banded antennae (*Polycyrtus* spp.). In Cuban collecting, on the other hand, one is impressed by the comparative abundance of beautiful metallic forms, with banded, dark-coloured wings (e.g. *Callicryptus* spp.) probably mimicking Pompilids of the genus *Pepsis*, likewise very plentiful there.

Stenarella brevicaudis, Szép. (ICHNEUMONIDAE.)

One male emerged from a cocoon of *Hypsipyla grandella*, in a fallen fruit of the Meliaceous tree, *Carapa guianensis*, at Mabaruma, British Guiana. When the moth-cocoon was opened carefully lengthwise, the Ichneumonid cocoon was found fastened tightly along one wall. It was 10 mm. long, cylindrical, with rounded edges, and made of very close-textured, dark brown silk, like brown paper. Emergence took place by an irregular hole at the anterior end. The host skin and head capsule were bundled up outside.

Polycyrtus sp. (ICHNEUMONIDAE.)

In rain-forest, Maracas, Trinidad, on 1st January, numbers of this and superficially similar forms of other genera were flying singly among the undergrowth. One female *Polycyrtus*, however, was attended by no fewer than three males, on adjacent leaves.

Chelonus insularis, Cress. (BRACONIDAE.)

This species was swept abundantly from grasses—chiefly *Panicum barbinode*—in cane-field intervals (*guarda rayas*) in Cuba, and in extraordinary numbers from pure stands of the weed, *Kallstroemia maxima*, where it was apparently searching for hosts, since the flowers were not visited. In Haiti it was very abundant on grasses infested with the Noctuids, *Laphygma frugiperda* and *Mocis repanda*, and was observed ovipositing in an egg-mass of the former.

Apanteles thurberiae, Mues. (BRACONIDAE.)

This is a solitary endoparasite of the pink bollworm (*Platyedra gossypiella*) at the Cotton Research Station, St. Augustine, Trinidad. The cocoon is pure white, of the usual shape, though often somewhat flattened or curved over on the attached side, and 5 mm. long.

Brachymeria annulata, F. (Chalcididae.)

Collected on *Piper* sp. and yams, St. Augustine, Trinidad, and hovering round cocoons of *Alabama argillacea*, " cotton worm," Damien, Haiti. Numbers of pupae of the latter were dissected and found to be parasitised to the extent of 4·8 per cent. by this Chalcidid and 2·4 per cent. by a Tachinid.

As many as three *Brachymeria* may mature in one host-pupa. The full-fed larva (earlier instars not seen) has a curious tail-appendage, drawn out into a distinct spine.

The pupae are black and lie completely naked in the entirely hollowed-out chrysalis of the host, the rest of the cavity being full of gas (air ?).

Brachymeria sp. (Chalcididae.)

This is a parasite of a mud-building wasp of the genus *Trypoxylon*. The colonial nest of the latter consisted of some 200 cylindrical individual cells covered by a common envelope, all plastered on the underside of a rock, near St. Augustine, Trinidad. A *Brachymeria* female was sitting three inches from the nest. It began slowly to advance, waving its antennae. It crawled upon the nest, and then seemed galvanised into activity, dashing over salient parts with great speed, crawling leisurely over lower portions hidden from the sight of the owners. Whenever at all near a wasp, it stopped dead. A wasp dashed at it. It flew at once, alighting on a leaf a foot distant, where it stayed some time. But again it approached the nest, with the same tactics and was again driven off. This was repeated six times, during which it entered two unoccupied nest-cylinders head first, but remained only a second. At too near an approach of a *Trypoxylon* it flew precipitately, whether chased or not. Eventually it entered one of the same holes *backwards*, and stayed two minutes, with its head visible at the entrance, antennae waving slightly; then left without the intervention of a wasp.

Later an adult was reared from a similar nest.

Brachymeria sp. (2) (Chalcididae.)

Another species of *Brachymeria* was reared from pupae of the moth, *Mocis punctularis*, infesting a waste-land weed, *Sida rhombifolia*, at Soledad, Cuba. Only one emerged, cutting a rough, round hole in the chrysalis, just below the shoulder. Parasitism was at the rate of 5 per cent. only.

Spilochalcis sp. (Chalcididae.)

Reared as a hyperparasite from a curious banded cocoon, suspended from a grass-blade by a thin silken line 65 mm. long. Near Princes Town, Trinidad.

Pentasmicra coccinea, Cress. (Chalcididae.)

The generic location of this most beautiful insect—crimson with black wings—I owe to Dr. Ferrière; for the specific identification I am responsible. One specimen was reared at Soledad, Cuba, from a very egg-like Limacodid (?) cocoon, glued to a leaf of *Acalypha wilkesiana*.

Notaspidium formiciformis, Walk. (Chalcididae.)

Two specimens were found in minute, pin-prick-like, smooth burrows in a knob of sedimental clay hanging to a rootlet under an overhanging bank, in second-growth rain-forest near St. Augustine, Trinidad (I. H. Myers). I could find no trace of food nor hosts.

Kapala cuprea, Cam. (EUCHARIDAE.)

This was reared from cocoons of the large black ant, *Pachycondyla crassinoda*, Latr., from a nest in the Northern Range, Trinidad, at about 1200 feet elevation. Three naked parasite pupae were found in one instance on the remains of the host-pupa within the ant-cocoon. From undisturbed cocoons the adult *Kapala* emerged by nearly cutting off a neat circular cap at one end.

Aximia sp. (EURYTOMIDAE.)

There is a curious item of behaviour to record on behalf of this species. Two insects were engaged on a small dead twig, four inches long, of *Cephaelis tomentosa*, near St. Augustine, Trinidad, in second-growth rain-forest. The twig showed a boring at the cut or broken tip. The *Aximia* was perched on the side of this dry twig, along which was flying a small Campoplegine Ichneumonid, with a dancing, gnat-like flight, and antennae outstretched, porrect, but slightly curved down at the tip, like those of a *Rhyssa* in search of *Sirex*—touching or nearly touching the twig along its whole length. Time after time the Ichneumonid danced in flight along the twig and back again, while every time the *Aximia* followed its course, running furiously up and down the branch and turning whenever the larger insect did do, as though to drive it away.

Ooencyrtus trinidadensis, Crawf. (ENCYRTIDAE.)

Reared from metallic coppery eggs of an undetermined Coreid on leaves of *Crotalaria*, Union Experiment Station, St. Lucia, 25th April. From the same lot of eggs was reared *Hadronotus rugosithorax*, Ashm.

Tetrastichus haitensis, Gahan. (EULOPHIDAE.)

During July and August, 1931, this egg-parasite of *Prepodes quadrivittatus* (in Haiti), of *Diaprepes abbreviatus* (in Porto Rico) and of *D. famelicus esuriens* (in Montserrat), was introduced by aeroplane and ship into Barbados, where Mr. Tucker, Government Entomologist, has reared several generations in the laboratory and already liberated large numbers in the field, with a view to controlling the cane root-borer, *Diaprepes abbreviatus*.

I am greatly indebted for courtesy, in connection with these shipments, to the Pan American Airways officials at Port-au-Prince, Haiti, and to Mr. H. E. Box and Mr. A. Pickles for transhipping arrangements in Antigua and Trinidad respectively, there being as yet no aeroplane service to Barbados.

Tetrastichus haitensis was the subject of preliminary studies near Port-au-Prince in November, 1929. It was then especially abundant in eggs of *Prepodes quadrivittatus* laid in the folded leaf-tips of papaya (*Carica papaya*) at the École Centrale at Damien. The rate of parasitism was 64 per cent. By an unfortunate misprint this appeared in a previous publication (*Empire Marketing Board*, **42** : 116) as 6 per cent. The host-eggs were much more abundant on those varieties of papaya with less dissected leaves, the broader leaf-tips evidently offering a better fold.

The adult parasites are very phototropic and are easily handled by utilising this trait. They copulated readily in 3 by 1 inch tubes. With moisture alone they survived in captivity four to five days, and with raisins no longer.

Parasitism of a given attacked egg-mass varies from about 25 to 100 per cent. Usually it was 100 per cent. The adults emerged through holes pierced in the two sides of the leaf-fold, one parasite often using a hole made by another. As many as 65 were reared from one egg-mass on *Ipomoea crassicaulis*, and from a second on the same host-plant, 58 were obtained. The numbers from papaya were smaller—13 to 38. From eggs laid on papaya in the field on 11th June, adult parasites emerged on 28th.

During the months June to August, 1931, the host was comparatively scarce at Damien and still more so in such other parts of Haiti as I was able to visit. At Cape Haiti the adults were reported as highly injurious to young grape-fruit trees earlier in the season.

In Porto Rico Mr. H. C. Osborn had found, at Central Aguirre, at least two other egg-parasites of *Diaprepes abbreviatus*, chiefly from egg-material laid between the stiff leaves of a species of *Ficus*. One of these was a giant Trichogrammatid and the other a *Tetrastichus* which Dr. Gahan has identified with *T. haitensis*. I am indebted to Mr. Osborn for information regarding these parasites.

On my return to Porto Rico in August, Mr. Osborn had left the country, and I was assisted most generously by Drs. Leonard and Wolcott. I wish also to thank Mr. E. Colon, Commissioner of Agriculture, for facilitating my work in such a whole-hearted manner.

The Trichogrammatid was found to be extremely rare at least at that season, but a plentiful supply of *T. haitensis* was secured from fig-leaves at Aguirre, and from leaves of seedling grape-fruit, 4 to 5 feet high, at Santa Isabela, on the north coast, where Dr. Wolcott had discovered it in the meantime, and where it was parasitising *D. abbreviatus* eggs at the rate of nearly 90 per cent. (estimate only).

Mr. Tucker finds that the Porto Rican race breeds much more freely and seems far more promising than the Haitian one.

Ootetrastichus sp. (EULOPHIDAE.)

Reared in numbers from a cluster of brown, papillated conical eggs of an unidentified beetle on a leaf of *Cordia cylindristachya*, Tunapuna, Trinidad.

Euplectrus platyhypenae, How. (EULOPHIDAE.)

This is a common parasite of full-grown larvae of *Laphygma frugiperda* on *Panicum maximum* and *P. barbinode* (Cuba), and of *Cirphis* sp. on sugar-cane and grasses in Trinidad.

In the case of *Cirphis* the remains of the host-caterpillar turn black but more or less retain their form, and sometimes a proportion of their contents becomes liquid; while the Chalcidid larvae, having emerged, pupate in small cocoons in a neat row beneath, gluing the host-remains to the leaf. These are hardly separate cocoons so much as cells in a fluffy mass of fastening silk, which protrudes along the sides of the caterpillar as a white fimbriate margin. The hyperparasite, *Horismenus nigroaeneus*, Ashm. (EULOPHIDAE), has been reared in Trinidad. It had not parasitised all the *Euplectrus* in the mass.

A *Horismenus* sp. was reared in Cuba, from *Euplectrus* on *Laphygma*, the tiny jet-black pupae lying one in each host-cocoon.

Hadronotus rugosithorax, Ashm. (SCELIONIDAE.)

Reared in company with *Ooencyrtus trinidadensis* (*q.v.*) from Coreid eggs on *Crotalaria*, St. Lucia.

In conclusion, I have much pleasure in thanking, for determinations, Dr. C. Ferrière (all Chalcidids unless otherwise stated), Mr. D. S. Wilkinson (all *Apanteles* and some other Braconids) and Mr. W. E. China (several Hemiptera).

THE INFLUENCE OF TEMPERATURE ON THE LIFE-HISTORY OF INSECTS

By Ernst Janisch.

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[Read December 2nd, 1931.]

(Communicated by B. P. Uvarov.)

With Nine Text-figures.

The influence of environmental conditions on the life-history of insects has recently been described repeatedly in special publications and particular books. The problem is (and will be more and more in the future) one of the most important ones in entomology, especially in applied entomology. It is certain that climate and weather (especially temperature and humidity) and the nature and condition of food have a great influence on the ecological distribution and the outbreaks of injurious insects and also of their parasites and diseases. Uvarov (1931) says: "Economic entomologists of the present day are no longer satisfied with merely recording the outbreaks of insect pests and with devising means for their control. They realise more and more that their chief aim and highest ambition must be to foresee and to prevent outbreaks. In order that they may be able to do this, all conditions accompanying and causing outbreaks must be thoroughly investigated and elucidated; in other words, the epidemiology of insect pests must be the central problem of economic entomological research, which should be carried out from the ecological point of view. The ecological conception of economic entomology consists in the recognition of the injurious insect as an integral part, and even as a product, of its environment.—Climate, then, is the ever-present factor in insect life.—The other conditions of environment are subordinate to it in importance.—Climate, however, is an extremely intricate complex of phenomena, and it is hopeless to attempt to study its influence on insect life by methods other than analytical. Each separate factor of the climatic environment should be studied by itself, and its effects on each phase of the insect's life should be investigated independently. This work belongs to the field of experimental physiology, which studies the responses of an organism to the controlled degrees of each isolated factor." But in the reports on these questions, we see repeatedly that the results of different authors are not homogeneous or synonymous, owing to the methods of investigation being different. The more we know of the phenomena of insect life, the greater must be the accuracy and exactness we demand of experiments and observations. Thus we can see that, up to now, many things have been disregarded, which, to-day, belong to the normal practice of the experimenter in biology. Therefore, it is impossible to compare directly the old-fashioned experimental work with the modern. This holds good both for the methods and the observations themselves. We must mention, however, that, to-day, nothing is organised, many old methods are used as before, the new ones have not yet been standardised, and, therefore, naturally, there must be a confusion in problems and terms, in methods and purpose of the experiment, and an attempt is therefore made here to find a way out.

I. LENGTH OF DEVELOPMENT AND TEMPERATURE.

The degree to which the length of development of an insect (and also the other reactions of life: respiration, activity, heart-beat, etc.) depends upon the temperature is an old problem. It has long been known that development takes a longer time at lower and a shorter time at higher temperatures. Many efforts have been made to express these relations as a mathematical formula. They are separable into two groups. The first of them is based on the velocity of reaction to chemical processes and represents an exponential function of various types (van t'Hoff's rule, Arrhenius' formula, the exponential law of Janisch). In the other group the product of temperature and time expresses a constant. The formula taken as this relation is a hyperbola (thermal summation, Belehradek's formula, Wardle's formula and others).

Naturally, a formula must have a theoretical basis and must correspond with the data observed. It is, then, certain that an exponential formula gives the best theoretical basis, since the chemical reactions, as well as the biological phenomena, at least depend upon the law of mass action from which the exponential formula (and therefore the exponential law also) follows automatically. Buddenbrock and Rohr say, of the respiration of insects, "The fact that the influence of temperature in chemical processes can be expressed by an exponential curve—*i.e.* that the velocity constant is an exponential function of the temperature—is a law on a theoretical basis and not merely an empirical rule. Therefore, we must try to conform with this law in some way." The same holds true for all other biological phenomena. On the contrary, the hyperbola in whatever form, has no theoretical foundation, only an empirical one.

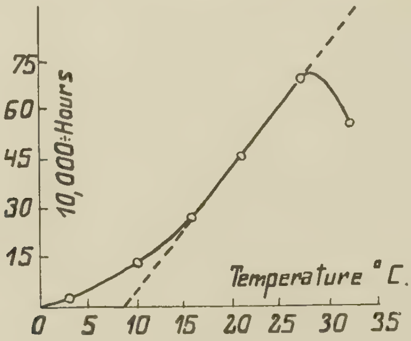

FIG. 1.—The velocity of development curve of the grain aphis. (After Shelford, redrawn after Uvarov.)

In many cases, if we recognise the biological reality of any formula, it is much easier to draw not the curve for the length of development, but the curve of the average velocity of development, as has been done in fig. 1. Then, the velocity $\left(v=\frac{1}{t}\right)$ shows an S-shaped curve, while the curve for the length of development is a more simply formed line, which has a minimal time value at a high temperature. The velocity curve is the reciprocal of the time curve. Now, it will be seen in what manner the curves, which are taken as a basis for the different efforts, follow their course. Suppose $t=$ time, $v=\frac{1}{t}=$ average velocity, $T =$ temperature in ° C.-units. It must be mentioned that these temperature degrees are not to be counted from the freezing point of water or from the absolute zero point, but they are merely degree-units on the abscissa. They must be counted from the mathematical zero point of each curve as origin, which must be considered, also as a biological zero point. All other letters are constants.

(1) The simple exponential curve $t = ma^T$ is shown in fig. 2. The reciprocal (R) has the same curvature as the time curve and does not show a sigmoid form. Fig. 2 shows, as broken lines, another kind of a simple exponential curve, where the axes are reversed: $T = ma^{-t}$ or $t = \frac{\log m - \log T}{\log a}$. The

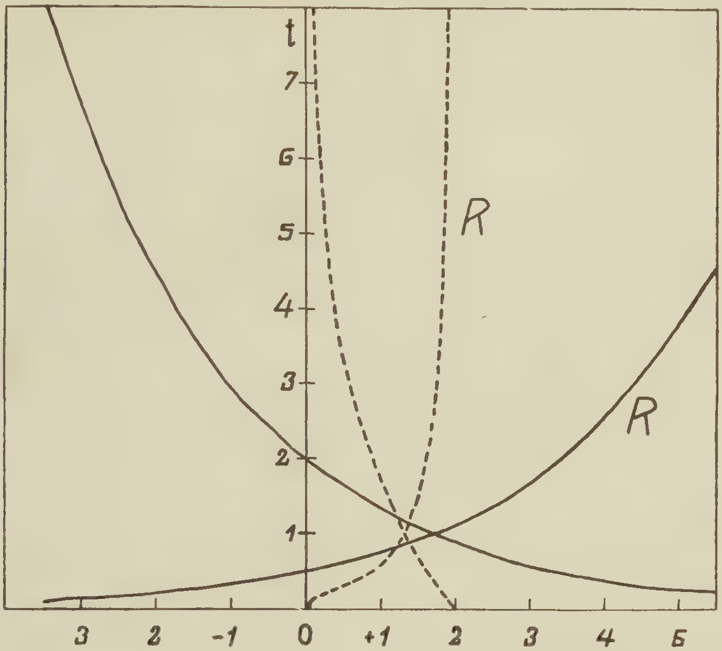

FIG. 2.—Two exponential curves with their reciprocals (R). Black line curve: $t = m \,.\, a^T$. Broken line curve: $t = \frac{\log m - \log T}{\log a}$; $m = 2$; $a = 1{\cdot}5$.

reciprocal of this curve shows, indeed, an S-shaped form, but the termini deviate in the opposite direction, as they do in the biological curve in fig. 1. Therefore, there is also no conformity with this exponential curve.

(2) The simple hyperbola $t \,.\, T = k$ is also often used in biology, in most cases with the form: $t \,.\, (T - c) = k$, where $T =$ temperature in ° C. above zero; $c =$ developmental zero point, *i.e.* the point, where the co-ordinates begin; k is a constant, called thermal constant or temperature sum. This last term is not quite correct, for the product, time × temperature, is not, as has been said, the sum of the different temperatures recorded every day which the organism needs to complete its development. A thermal sum would be a quantity of calories, as is used in the term "heat tone" (compare, *e.g.*, the constant μ in Arrhenius' formula). Fig. 3 shows this hyperbola with its

reciprocal as a straight line. This one agrees with the biological curve only in its middle part. Another kind of hyperbola is to be seen as a broken line in fig. 3 with a formula used by Belehradek: $tT^b = k$. The reciprocal of the curve is the parabola: $t = \frac{1}{k} T^b$. No sigmoid curvature is present.

(3) The catenary curve $t = \frac{m}{2}(a^T + a^{-T})$ has the same theoretical basis as the exponential curve and agrees well with the experimental data (black line in fig. 4). I call such a curve a complex exponential curve as opposed to the simple one, which has the formula $y = ma^T$. The curve for the length of development shows a minimum, which the other curves do not; and the reciprocal has the same S-shaped form as the biological curve.

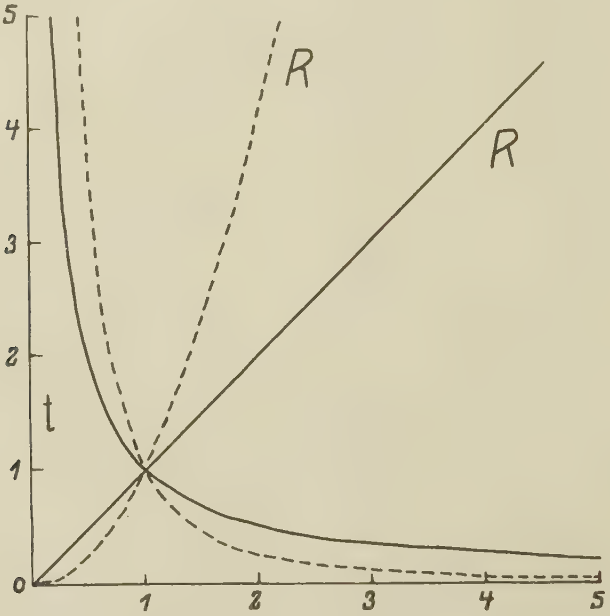

FIG. 3.—Two hyberbolae with their reciprocals (*R*). Black line curve: $t \,.\, T = k$. Broken line curve: $t \,.\, T^2 = k$; $k = 1$.

(4) The parabola $t = \frac{T^2}{2p} + q$ in fig. 4 (broken line) has, indeed, also a minimum for the shortest time of development, and the reciprocal shows the same S-shaped form as the reciprocal of the catenary curve, but no theoretical basis is found for it. In this case the agreement with biological data must demonstrate the truth of this formula. In fig. 4 are seen a catenary curve and a parabola, both of which are calculated from the same two points marked as black spots. Fig. 4 shows that these two curves take a different course. This holds true, naturally, for the reciprocals. It may now be considered how closely the different formulae correspond to the biological curve. For this purpose, the embryonic development of the meal moth *Ephestia kühniella* has been taken. In 1925, I showed the close approximation of the catenary curve

to this development. The black spots in fig. 5 show the experimental data and the range of variation. The shortest time (3·75 days) for development was observed at 28·6° C.

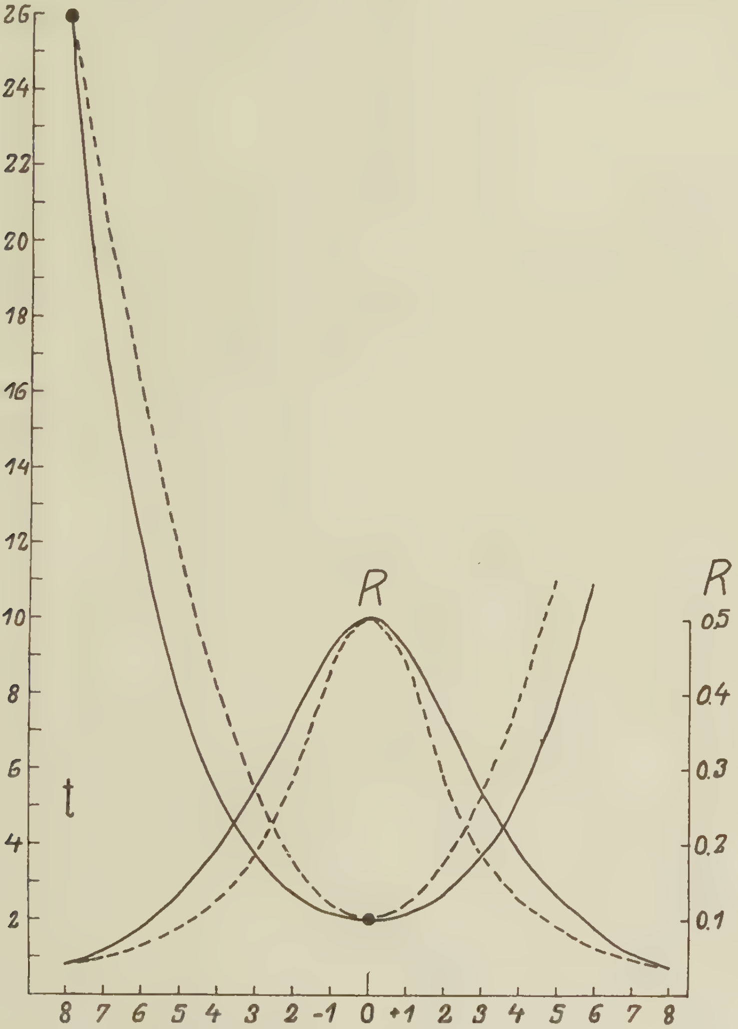

FIG. 4.—Black line curve: the catenary curve $t=\frac{m}{2}(a^T+a^{-T})$; $m=2$; $a=1{\cdot}5$. Broken line curve: the parabola $t=\frac{x^2}{2p}+q$; $q=2$; $p=1{\cdot}338$. Both calculated with the same data marked as black spots. $R=$ the respective reciprocals.

(1) Curve 1 is the exponential curve $t=\frac{\log m - \log T}{\log a}$.

Biological data for calculating :

$t_1 = 3{\cdot}75$ days at 29·6° C. = 302·6° abs. temp.
$t_2 = 22$ days at 13·6° C. = 286·6° abs. temp.

T° counted from the absolute zero point (— 273° C.).
$\log m$ calculated $= 2{\cdot}48572$; $\log a$ calculated $= 0{\cdot}001275$.
The curve deviates widely from the points in medial temperatures.
(2) Curve 2 is the exponential curve $t = ma^T$.
Biological data for calculating as in curve 1.

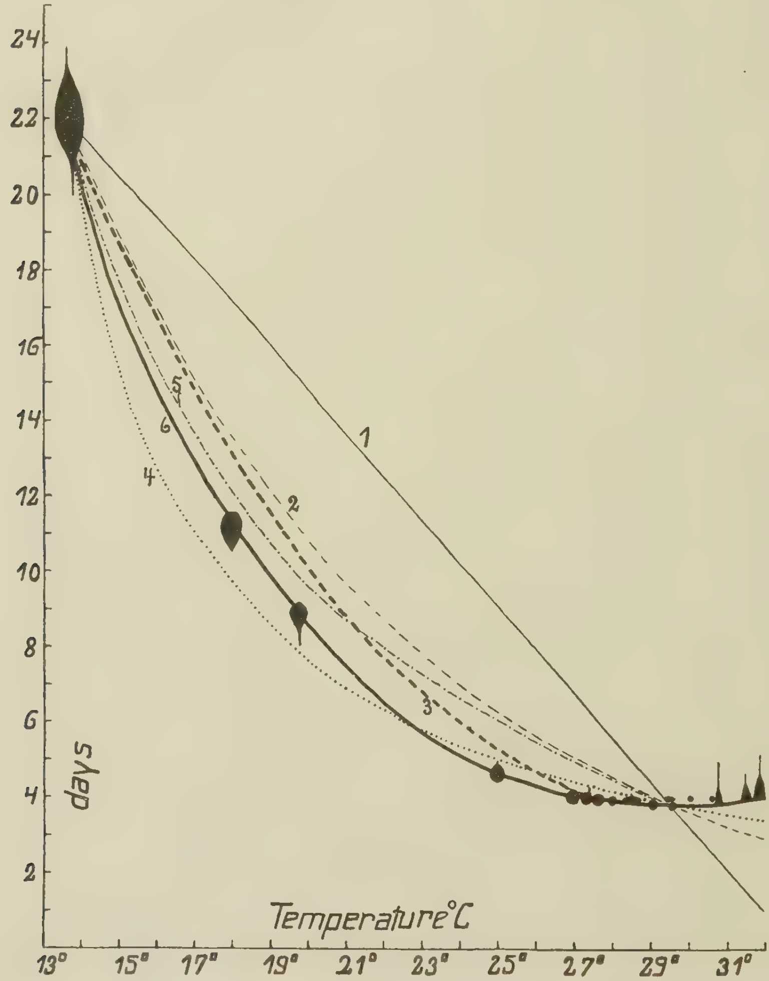

Fig. 5.—The length of the embryonic development of *Ephestia kühniella* represented by different formulae. The heavy black line curve (6) is a calculated catenary curve: $t = 1{\cdot}88\,(1{\cdot}164^T + 1{\cdot}164^{-T})$ with 29·6° C. as origin.

T° counted from the point 29·6° C. as origin, where the shortest time for the development is observed, *i.e.* the developmental optimum (for the egg) in the old sense. Then, m is the time observed at 29·6° C. $= 3{\cdot}75$ days. a calculated $= 1{\cdot}117$. The curve approximates nearer than 1, but yet deviates from the observations.

(3) Curve 3 has the parabola $t = \dfrac{T^2}{2p} + q$.

Biological data for calculating as in curve 1.

$T°$ counted from 29·6° C. as origin; q has the same value as m in curve 2: $q = 3{\cdot}75$ days. p calculated $= 7{\cdot}02$.

The curve comes nearer to the observed points in the neighbourhood of its origin, but it deviates in the medial temperatures (compare the curve in fig. 4).

(4) Curve 4 is the hyberbola commonly used, $t(T - c) = k$, where T means ° C. counted from the freezing point of water and c the developmental zero point.

Biological data for calculating:

$$t_1 = 4 \text{ days at } 28{\cdot}6° \text{ C.}$$
$$t_2 = 22 \text{ days at } 13{\cdot}6° \text{ C.}$$

c calculated $= 10{\cdot}26°$, k calculated $= 73{\cdot}5$.

The curve lies much lower than the others, but also deviates in the medial temperatures.

(5) Curve 5 is the hyperbola used by Belehradek: $t \,.\, T^b = k$.

Biological data for calculating as in Curve 1.

b calculated $= 2{\cdot}16$, k calculated $= 6180$.

The curve lies, in medial temperatures, on the other side of the biological data to curve 4, but deviates much more from the points at higher temperatures.

(6) Curve 6, finally, is the catenary curve, $t = \frac{m}{2}(a^T + a^{-T})$, the resultant of two exponential curves, which cross each other.

Biological data for calculating as in curve 1.

m is the observed shortest time for the development $= 3{\cdot}75$ days. a calculated $= 1{\cdot}164$.

It is evident that this curve gives the best approximation. All observed points lie on this catenary curve. The fact that the catenary curve is the most correct one for a time curve and its reciprocal for a velocity curve is verified by the observations of different authors in many examples, which show a minimum of the time curve and a maximum of the velocity curve (see, *e.g.*, Shelford, Uvarov, Janisch, Hase, Börner, Anderson, Weber). Therefore, the first objection that the experimental data are too few for the biological truth of the catenary curve holds true no longer. On the contrary, there are, to-day, more data that apply to this curve than in many other cases in biology.

In spite of this real evidence, there still remains something to be said about the different curves, since there is much confusion in the literature. If it is desired to understand the real character of the curve for the length of development, it must be borne in mind that the development of any stage is only a part of the total individual life-cycle, which begins with birth and ends with death. In the same way, the time for the development of a stage is, naturally, a part of the total duration of life. Therefore, it is impossible to isolate a partial development from the life-history as a whole. We know that the duration of life is relatively short at very high temperatures, *e.g.* at 100° C., where a newly laid egg will die in a few seconds, but, the more the temperature decreases, the longer is the duration of life. In temperatures that are relatively lower, development takes places in the egg, but the organism dies without hatching. This relation between high temperatures and duration of life is called sterilisation. The same holds true for insects breeding without interruption or for growing stages in very low temperatures. The nearer the temperatures lie in a biological medial zone, the longer is the duration of life and the further the development proceeds. These phenomena are demonstrated in fig. 6 by the cotton worm, *Prodenia littoralis,* which I studied in Egypt.

The curve for the duration of life is composed of three parts : the curves of sterilisation at high and low temperatures and a middle part in the vital zone, which represents a catenary curve as in fig. 7. If we summarise all our knowledge of the total duration of life and sterilisation at low temperatures it will be found that the decrease in lower temperatures holds good for the observations of organisms without a rest-period. At each temperature, the duration of life is limited in time, *i.e.*, in no temperature can the insect live indefinitely as is presumably the case for the developmental zero point. At different temperatures, the insect does not die at the same stage, but death occurs in high and low temperatures at the egg stage, in more medial temperatures at the different larval stages, then, at the pupa stage and at last—but only in medial, *i.e.* vital temperatures—adults are able to develop. The limits of this vital zone are not sharply defined. Adults reared in a temperature very near this limit, are infertile (*c* in fig. 7); in a temperature which is somewhat more medial, the adult has a low egg-production and dies very soon after emergence (*b* in fig. 7). In the middle part of this zone (*a* in fig. 7), here called optimum, are found adults, which complete the total individual life-cycle of the species and die by natural physiological death. Between *a* and *c*, all integrates can be found.

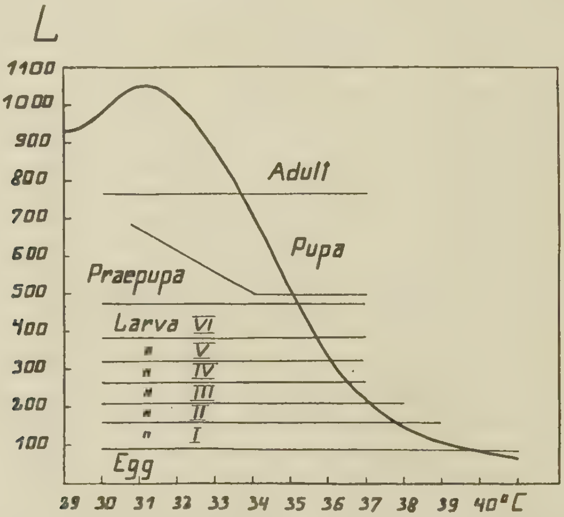

FIG. 6.—The duration of life of *Prodenia littoralis* at different high temperatures. The points where the horizontal lines cross the curve indicate at which stage death occurs at the respective temperature.

It must be mentioned that this curve for the total duration of life now holds true only for insects without rest-periods, because there are many investigations on the cold hardiness and cold resistance of insects, which complicate the problem. Three groups of investigations are to be distinguished : those on stages in, or at the end of, the rest-period and those on growing stages. The comparison of these groups of results is very difficult. It seems as if such a separation is not always carried out and as if the observations of these three groups are compared without consideration for the previously mentioned types, as it may be with the so-called stimulation by cold. Such observations on stages in their rest-period must be separated from the normal course of development and cannot be considered objections against conclusions concerning the normal development. It is certain that the scheme for insects breeding without interruption is much simpler, and I believe that it will be better and more convenient to begin with a simple case than to make out the essentials

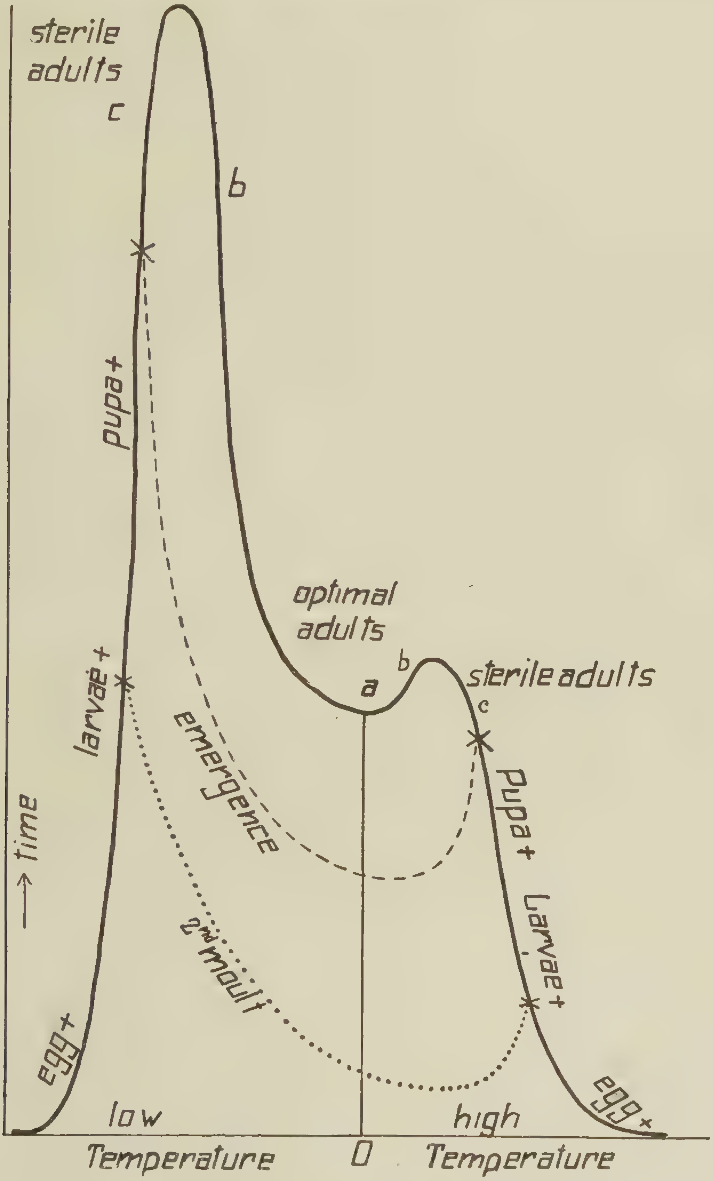
sterile adults
c
b
pupa+
larvae+
→ time
egg+
low
Temperature
optimal adults
a
b
sterile adults
c
emergence
2nd moult
Pupa+
Larvae+
egg×
high
0
Temperature

FIG. 7.—Diagrammatic representation of the relation between total duration of life of an insect and temperature. + = dead. Broken-line curve: length of development till emergence; dotted curve: length of development till the second moult.

of insect reaction on very complicated life-cycles. The curve of the insects with an obligatory rest period, shows perhaps three maxima, but nothing is known definitely on this point.

The curves for partial developments must be placed in the curve of the total duration of life, as I have done in fig. 7. The dotted line is the curve for the time from birth to the second moult, and the broken line is the curve for the time from birth to emergence. The curves hang like a chain between the branches of the curve for the total duration of life. We see that the catenary curves are not symmetrical ones. The phenomena of development through several stages are much more complicated than in fig. 5, where we considered the embryonic development only.

Naturally, the curve has a different course, where the experiment begins with the newly laid egg, and where each stage is observed separately. If the temperatures alternate and only older stages are investigated, the curve of life expectation takes the place of the curve for the duration of life. Here, we will only consider the total individual life-cycle beginning with the egg, if development occurs in each temperature till death, *i.e.* we include the adult life till physiological death takes place. We see, then, that at the intersections of the curves the catenary curve for any partial development ceases, since at higher or lower temperatures than these intersections, where the chain is fixed, development does not continue until the respective stage but stops at an earlier stage. The optimum for total development lies at that temperature, where we get adults of full physiological value, *i.e.* where the adults lay the greatest number of fertile eggs and die a physiological death. That is the same temperature where the total development from egg to physiological death (*i.e.* the total life-cycle) is completed in the shortest possible time. It is clear then, that the shortest time for partial development is not the optimum for the species, but only a minimum for the respective stage. This minimum lies (see fig. 7) at a temperature which is higher the less completely development has advanced, *e.g.* at a higher temperature for the embryonic development than for development up to the second moult or even to the emergence of the imago. That means, it is impossible to define a special optimum for each stage, if we recognise as optimum that temperature in which the individual shows its maximum efficiency. The true developmental optimum can be related only to the total individual life-cycle and is, at the same time, the origin of the catenary curves of all stages. It is the same whether the insect remains its whole life in the same temperature or not.

The formula for the asymmetrical catenary curve is $t = \frac{m}{2}(a_1^{T} + a_2^{-T})$. Its minimum is not the origin, and, therefore, this asymmetrical catenary curve is a good approximation to the biological situation. The calculation of the constant a in the symmetrical catenary curve is very easy, if we remember that the second part of the formula is an exponential curve with a relatively low numerical value at a low temperature. Thus, we can ignore this part, and the equation becomes $t = \frac{m}{2} a^{T}$ and $\log a = \frac{\log 2t - \log m}{T}$. The value of a thus obtained is only approximate; but it is not difficult to determine the real value by tests.[*] For the asymmetrical catenary curve, we must calculate the approximate value of a_1 by neglecting the part a_2^{-T}, and the approximate value of a_2 by neglecting the part $a_1{}^T$. We shall get the closest approximation if we take as a basis the highest points of the curve, which are identical with the points on the curve for the duration of life. Naturally, it is also necessary to know the optimum, *i.e.* the origin, which gives, in addition, the value of m for each partial development. Therefore, we can say : if we know the curve for the duration of life and the stage that can be reached by the species at each temperature (as may be seen, for supra-optimal temperatures, in fig. 6 for *Prodenia littoralis*), it is possible to calculate the curve for each stage. Considered from this point of view, we must conclude that we still know little about the total life-history of insects.

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[*] Naturally, the value of a can be calculated directly with the quadratic equation $t = \frac{m}{2}\left(\frac{a_2^{T} + 1}{a^{T}}\right)$.

The descending branches of the curve for the duration of life, and, especially, the ascending part of the catenary curve for partial developments in higher temperatures above the optimum, lie in a narrow temperature zone. Therefore, in many cases, experimenters could not find these ascending parts of the curve, since few investigations are made at really constant temperatures, but the data are mean values of relatively large temperature variations. Just at this zone where the curves descend precipitously, there are small variations which modify the phenomena considerably, *e.g.* the time and the death point in development. Moreover, the influence of other factors (humidity, hunger, etc.) is important just at these limits, if these factors deviate from their own optima. Thus, in this zone, the biological reactions are very complicated. It is evident that exact results can only be obtained if experimental work is done with the best methods in really constant conditions and bearing in mind all the knowledge of these phenomena available. This holds true not only for the temperature, but also for humidity, food, oxygen supply, light, etc., which must be at their optimum, if we wish to see the pure effect of temperature. Likewise, if investigations are made of the influence of different humidities, food, quantities of light and so on, the temperature must be constant. It cannot be said that these exact conditions have been carried out for all investigations of this problem, and there may be, in the literature, some observations which are not quite correct and which are still taken, to-day, as a basis for objections against this or that conclusion. Later in this paper further arguments will be given in support of this view.

Now, if we again consider the different attempts at a solution of the temperature problem, we must take as a basis that the duration of life is limited in time at each temperature. This should of course be evident, since we know no instance of individual immortality among insects. Therefore, each attempt which takes such an immortality as a basis (*e.g.* as the hyperbolae in fig. 3 or the broken-lined exponential curve in fig. 2 do with their origin), cannot be sufficient. With the hyperbola, such a temperature has been called the developmental zero point, which has been defined as that temperature below which it is theoretically possible to preserve insects alive at a given stage for an unlimited time. However, later on, in consideration of the above-mentioned fact, this point has been defined by Bodenheimer, 1930, as that temperature below which a complete development to the adult cannot take place. But, since that temperature is a point with a temporal limit for the length of development, it cannot be the origin of the hyperbola in question. It is identical to the point where the broken-lined curve in fig. 7 crosses the left branch of the curve for the duration of life. Thus, the curve loses its character as a hyperbola by this new definition. Furthermore, all theoretical conclusions derived from the hyperbola are no longer valid (*e.g.* the temperature coefficient b in Belehradek's formula as indicator for cytoplasmatic phenomena). The same holds true for the exponential curve in fig. 2 van t'Hoff's rule being verified, as the formula for the catenary curve shows, for the cytoplasmatic partial processes, but not for the biological phenomenon in its entirety.

Two temperature coefficients are derived from the simple exponential curve for different biological phenomena : Q_{10} and μ. It has been known for a long time that these coefficients are not constant. Now, if we consider the catenary curve and its reciprocal as the most correct curve for the respective biological phenomena, we must find the same decreasing and changing of the Q_{10}-value in the catenary curve. We will take the reciprocal of a catenary curve with $m = 2$ and $a = 1{\cdot}8$. Five degrees Celsius is taken for each x-unit and $x = -6 = 10°$ C. Thus the resulting values for Q_{10} are as given in Table 1. We see that Q_{10} decreases if the temperature falls or is increased and decreases with a small change of temperature as it does with biological processes. Another temperature coefficient is the μ of Arrhenius' formula. This μ has also an exponential curve as a basis : $k_2 = k_1 \,.\, e^{\frac{\mu}{e}\frac{T_2 - T_1}{T_2 \cdot T_1}}$. If we calculate μ in a similar manner, we get the values of μ in Table 1. The table shows the same changes of μ that are already known in biology. In fig. 8 the curve demonstrates, that the values of Q_{10} and μ depend directly upon the curvature.

Tab. 1. The values of Q_{10} and μ calculated with the reciprocal of a catenary curve. $m = 2$; $a = 1{\cdot}8$.

Temp. ° C.	Q_{10}.	Temp. ° C.	Q_{10}.	Temp. ° C.	μ.	Temp. ° C.	μ.
0–10	3·24	20–22	3·1	0–5	15110	25–30	19180
10–20	3·21	22–23	3·29	5–10	18560	30–35	15320
20–30	2·98	23–24	3·0	10–15	18920	35–40	6260
30–40	1·77	24–26	2·95	15–20	19720	40–45	– 6260
40–50	0·846	26–28	2·91	20–25	19700	45–50	–15320

It must be mentioned that, in the original formula, A is written instead of μ. Many authors designate μ as the temperature coefficient in the sense that it means the quantity of calories which the organism consumes in completing its development. In chemical processes, μ signifies the heat tone, recorded in calories. That is correct, of course, for definite chemical reactions, but it is difficult to accept this term without hesitation for complicated protoplasmic processes, *e.g.* development, respiration, growth of organisms, etc. At all events, the heat tone has nothing to do directly with the dependence of development upon temperature. It must be added that $\frac{\mu}{2}$ cannot be recorded as calories, as seems to be done in some publications. The denominator value 2 is not a number, but the gas constant $R = 1{,}986 =$ about 2 calories. Therefore $A = \frac{\mu}{2}$ is a pure number. I suggest, therefore, that the sign A of Arrhenius' formula be used in place of the " heat tone " in describing biological processes, since such usage of A is usual in chemistry.

Of course, each small part of a biological curve can be expressed by a mathematical formula. It is common in biology to draw a bent curve as two or three straight lines. The respective formulae hold true, then, only for the given limits. Such an equation can be used for practical purposes, but such formulae are not suitable for the deduction of a theoretical law. The aim of my investigations was to work out a formula which is valid for all temperatures. I hope that I have been able to show that the theoretical foundations and the experimental data give evidence of the biological reality of the catenary curves. They are a part of the general biological law which I have called (1925) the "exponential law." Every formula which has an exponential character, *i.e.* in which the independent variable x is written as an exponent or in a logarithmic form, fulfils the conditions of the exponential law and is a special case of it. Therefore, all general conclusions that are based, *e.g.*, on the values of Q_{10} or μ or A respectively, correspond to the theoretical basis of the exponential law. However, it is just these fluctuations of Q_{10} and μ which show that, in most cases, the biological reactions cannot be explained by the simple exponential curve, but more complicated formulae must be selected, although, for limited parts of any curve, the simple exponential curve may be a good and theoretically well-founded approximation. I have already published (1927) such combined exponential curves to show the essentials of the exponential law; I intend shortly to publish more definite communications about these curves and their relations, which will show the way to a natural analysis of the phenomena of life and nature.

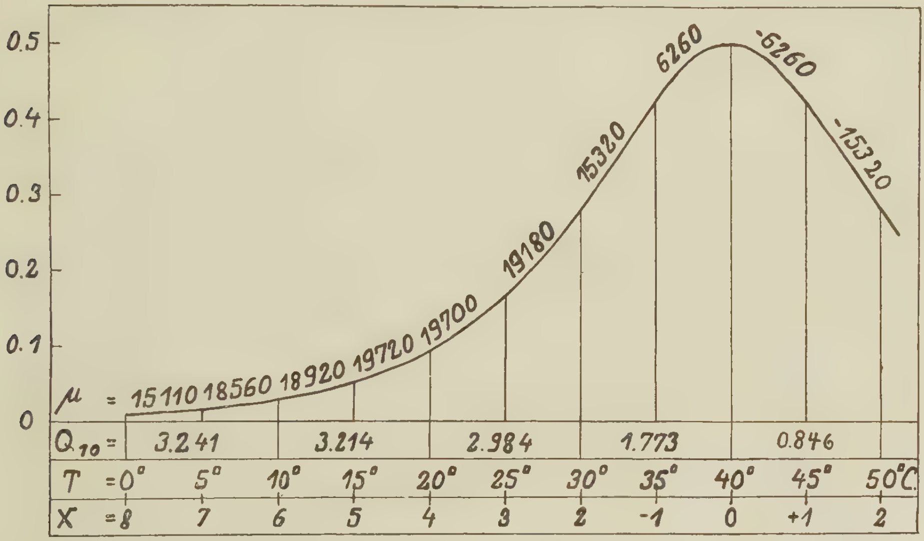


FIG. 8.—The values of μ and Q_{10} calculated with the reciprocal of a catenary curve depend upon the curvature in the same way as with a biological curve.

In the literature, an objection has been raised that the formula for the catenary curve has too many constants, but this is not the case, since the symmetrical catenary curve contains only one constant (a). The value m is an observed biological datum, *i.e.* the minimum of the curve. In the formula for the asymmetrical catenary curve, there are also only two constants (a_1 and a_2), which must be calculated, since we intend to find out the curve for the total duration of life and the optimum; then, m is the length of development in the optimum, *i.e.* an observed biological datum.

In different publications, it has been maintained that the middle part of the curve in the vital zone should be sufficient for ecological and epidemiological purposes, especially for calculating the number of generations. That is possible, of course, so long as absolute exactness is not demanded. However, it must be added, that those temperatures outside the vital zone together with all other environmental factors, are just those responsible for the ecological distribution of a species and the possibility of an outbreak. Therefore, a formula which is explicitly limited to the vital zone or only to a part of it, cannot be helpful to ecology and epidemiology, especially, if the observations are few in number.

II. THE COURSE OF DEVELOPMENT.

In the last section, we have considered the development only at constant temperatures. If temperatures are alternated during development, it is necessary to include the temporal course of development in the calculation. We have stated that the velocity of development is the reciprocal value of time in regard to the physical relation $v = \frac{s}{t}$. The value s, which means in physics a path of motion, has been equated in biology to some number, generally 1; but, in this equation, this path must have a biological sense and means, so to speak, the development itself, which follows its course during the individual life from birth to death. Then $s = v \, . \, t$ is an equation, in which we do not know the numerical value of s. The equation is the formula of a uniform motion with a constant velocity of a body which never comes to rest. Development is metabolism, *i.e.* it has also the character of a movement. Shelford (p. 180) says: " The meaning of velocity as applied in this way is well illustrated by reference to rate of movement, or speed of travel, of a machine or animal or man. In all matters of speed of travel, the reciprocal of the time required to cover a fixed distance is used to represent relative velocity, or rate of travel."

In contrast to the case of uniform motion, however, the biological development ceases, when the individual dies. The velocity of development cannot be a constant, therefore, but is a function of time. This holds true in all temperatures, not only in higher ones, as is mentioned by Belehradek. The velocity decreases when development follows its course and is equal to zero, when the organism dies. Now, we can say

$$\frac{ds}{dt} = v = P - gt,$$

a formula that corresponds to the equation of the uniformly retarded motion in physics. P is the velocity at the beginning of the movement, *i.e.* the individual developmental power at birth, a value that is a general constant of the species. The constant of retardation is g, which has a different numerical value at each temperature, since the duration of life is also different. We get by integration:

$$s = \int (P - gt) dt = Pt - \tfrac{1}{2} g t^2 + K.$$

I have shown with *Prodenia littoralis*, that we get useful results in the optimum and in higher temperatures, if we, at first, put $K = O$.

Then $$s = Pt - \tfrac{1}{2} g t^2.$$

We have seen in the first section that the development in the optimum follows its course through the total individual life-cycle from birth to physiological death. At the death point, we get then

$$v = P - g_0 L_0 = 0,$$

if g_0 is the constant of retardation in the optimum and L_0 the observed total duration of life there. Now, if we divide the individual life-cycle into 100 equal parts, then, at birth, s has the value 0 and at death from old age the value 100, which we may call $S_0 = 100$. The value of S means in the course of development the death point, which is in the optimum 100, but which must have a different value in any other temperature, since death occurs not at the extreme point of the life-cycle, but at a less complete point of development. In the optimum, we find then

$$L_0 = \frac{P}{g_0}$$

$$s = S_0 = PL_0 - \tfrac{1}{2}g_0 L_0^2 = \frac{P^2}{2g_0} = 100.$$

Then $$P = \frac{2S_0}{L_0} = \frac{2\,.\,100}{L_0} \text{ and } g_0 = \frac{2\,.\,S_0}{L_0^2} = \frac{2\,.\,100}{L_0^2}.$$

For *Prodenia littoralis*, at 29° C., $L_0 = 938$ hours, $S_0 = 100$ and, therefore, $P = 0{\cdot}2132$ and $g_0 = 0{\cdot}00022727$. Now there is the question of what numerical value shall be given to the different developmental stages. It follows from the equation $s = Pt - \frac{1}{2}g_0 t^2$, which we suppose indicates the course of development better than the equation $s = v\,.\,t$, used hitherto, that a definite value of s corresponds to an observed value of the time t, since, as with the movement in physics, a definite amount of development takes place in this time. Then we get by calculation the numerical value of s for each stage, if we observe the times for the different biological phenomena such as hatching, moulting, etc. (Table 2). In addition, a definite value of the velocity v belongs to each phenomenon, as illustrated in Table 2. The length on the develop-

Tab. 2. The development of *Prodenia littoralis* at its optimum (29° C.) regarded as a retarded motion. The length of development (t in hours) from birth to death, the path of development (s), and the developmental velocity (v).

Stages.	Time, t.	Path, s.	Velocity, v.
Birth	0	0	0·2132 (= P)
Mandibles visible	25	5·26	0·2075
Mandibles dark brown	35	7·32	0·2053
Egg becomes black	40	8·35	0·2041
Hatching	45	9·36	0·203
1. moult	84	16·92	0·1941
2. moult	107	21·96	0·1889
3. moult	147	28·91	0·1798
4. moult	180	34·76	0·1724
5. moult	219	41·28	0·1635
Praepupa	283	51·64	0·1489
Pupation	303	54·19	0·1444
Emergence	435	71·2	0·1145
Maturity	459	73·93	0·1091
Beginning of old age	720	94·35	0·0497
Death by senility	938	100	0

mental path, so to speak, is recorded in developmental units as they are obtained by dividing the development from birth to natural death in 100 units. This term "developmental unit" has nothing to do with the same expression much used in entomological literature for values of time (see, *e.g.*, Shelford). It is an absolutely new unit, which may be called "developmental degree" in order to avoid a confusion of terms. The new unit is by no means a time in per cent. as may perhaps be assumed, since the unit is only given by $S_0 = 100$. The expressions P and g_0 include this unit. It is easy to show the physical dimension of this developmental unit by calculation, if we put P and g_0 into the equation for development:

$$s = \frac{2S_0}{L_0} t - \frac{L_0^2}{S_0} t^2.$$

Then

$$s = \frac{2 \,.\, \text{devel. units} \,.\, \text{time units}}{\text{time units}} - \frac{\text{devel. units} \,.\, (\text{time units})^2}{(\text{time units})^2}$$

$$s = 2 \,.\, \text{devel. units} - \text{devel. units} = \text{devel. units}.$$

I have shown with *Prodenia littoralis* that the formula for the course of development holds true for temperatures of 34° to 40° C., in which the constant g does not always have the same value as is shown in Table 3. In the same way, the death point S, *i.e.* the final stage at which the individual dies at different temperatures, recorded in developmental degrees, is a function of temperature as fig. 9 illustrates.

Tab. 3. The duration of life (L_T in hours), the death point (S_T in developmental degrees), and the constants of *Prodenia littoralis* at different temperatures (T).

T.	L_T.	S_T.	g.	Quadratic equation.		Cubic equation.	
				h.	K_T.	$10^{-8}\,h$.	C_T.
29° C.	938	100	0·0002273	0	0	0	0
30°	980	99·4	0·000228	0·0101	10	2·146	3·2
31°	1050	98·7	0·000229	0·027	27·3	4·96	8·4
32°	1007	97	0·00023	0·0183	19·5	3·62	7·4
33°	890	91	0·000244	0·0038	5·7	0·96	3·3
34°	712	75·9	0·0003	0·0003	~0	~0	~0
35°	507	54·1	0·00042	0·0001	~0	0	0
36°	333	35·5	0·00064	~0	0	0	0
37°	218	23·2	0·00098	0	0	0	0
38°	150	16	0·00142	0	0	0	0
39°	109	11·6	0·00195	0	0	0	0
40°	85	9·1	0·0025	0	0	0	0

The introduction of such a developmental unit is important for the calculation of the effect of alternating temperatures. The retardation at a given temperature has not the same value in the time unit as the acceleration at another temperature. Therefore, the true total effect of different temperatures can be calculated only by consideration of the temporal course of development. The development of an insect occurs in the temperature T_1, with the retardation constant g_1, in the time t_1, to the developmental degree s_1 (*e.g.* hatching $s_1 = 9{\cdot}36$ for *Prodenia*):

$$s_1 = Pt_1 - \tfrac{1}{2}g_1t_1^2.$$

The corresponding velocity is v_1, which depends upon g_1. Then, the organism enters on the developmental stage s_1 with the velocity v_1 into the new temperature T_2. The development then proceeds to the stage s_2.

$$s_2 = s_1 + v_1t_2 - \tfrac{1}{2}g_2t_2^2$$
$$v_2 = v_1 - g_2t_2.$$

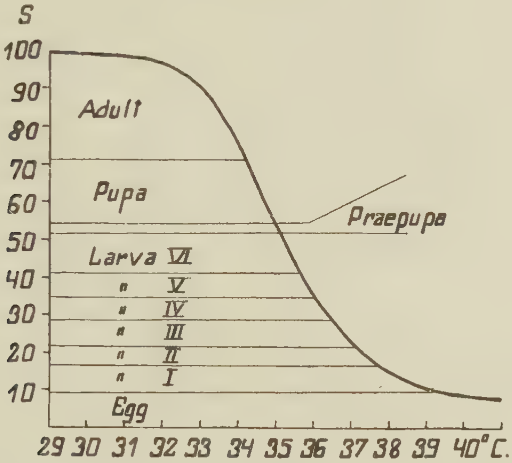


FIG. 9.—The death points (S) of *Prodenia littoralis* in developmental degrees at different high temperatures.

In the third temperature T_3, the development continues till death and follows the equation

$$s = s_2 + v_2t_3 - \tfrac{1}{2}g_3t_3^2,$$

by which the time (t_3) of the following moults, pupation, and emergence can be calculated by the methods for quadratic equations:

$$t_3 = \frac{1}{g_3}(v_2 - \sqrt{v_2^2 - 2g_3(s - s_2)}).$$

The total duration of life

$$L = t_1 + t_2 + t_3.$$

At death

$$v_3 = \frac{d(s - s_2)}{dt_3} = v_2 - g_3t_3 = 0 \text{ and } t_3 = \frac{v_2}{g_3}.$$

The death point S, *i.e.* the stage, at which the individual will die, is therefore

$$S = s_2 + \frac{v_2^2}{2g_3}.$$

I have calculated by methods of computation, which I can only briefly indicate in this paper, the observations made in Egypt on more than 1000 experiments with *Prodenia littoralis*. Details are given in my 1930 publication.

The experiments are made with regard to the relative humidity, since *Prodenia* is fond of moisture. They are divided into two groups: the continual influence of temperatures on the total life-cycle, and the temporary influence of different temperatures in several intervals of time with successive transfers into the optimum of the species (29° C.). The problem was to calculate all observed times by the same group of formulae with the same constants. There was a great variation in the time of exposure at different injurious temperatures and in their after effect in the optimum, which can be observed as a change of the length of development of the stages, and of the death point. Therefore, it was necessary to calculate the developmental degree at each stage and the values of g, etc., in all directions with the observations of any one experiment, and then to calculate back the times of all other experiments. The fact that it was possible, at last, to get a sufficient conformity of all observations and calculations in this way, is an important argument for the verity of the assumption that development can be regarded as a retarded motion. In Egypt, only a certain group of temperatures has been investigated. The above-mentioned formulae hold true, therefore, only for these temperatures, but the material is large enough to show the way that must be followed in the future to conform with natural conditions. Table 4 shows the conformity of observation and calculation on some examples. Eggs of *Prodenia* laid at 29° C. and remaining there several hours before the experiment began, were put into 37° C. and, after 22·5 hours, brought back into 29° C. The numbers are the hours, after which hatching, moulting, etc., takes place. The calculation was carried on in three stages :

Tab. 4. The observed and calculated times (in hours) of the development of *Prodenia littoralis* at 29° C. after a short exposure of the eggs to high temperatures.

Stages.	37° C. : 22½ hours.		40° C. : 6¼ hours.		40° C. : 10 hours.	
	t, obs.	*t*, calc.	*t*, obs.	*t*, calc.	*t*, obs.	*t*, calc.
Hatching . .	< 26	23	< 43	39	< 64	37
1. moult . . .	< 74	65	< 92	81	< 94	81
2. moult . . .	<104	95	<121	109	<136	112
3. moult . . .	<145	139	<161	150	<166	156
4. moult . . .	<176	173	<195	189	<207	196
5. moult . . .	<243	218	<237	231	<280	244
Praepupa . .	<315	297	<331	308	<325	319
Pupation . .	<346	318	<360	328	<383	350
Emergence . .	<513	490	<554	490	<542	540

(1) In the period at 29° C. after oviposition a slight development already occurs : $t_1 = 3$ hours. It must be mentioned that many eggs are laid in a short time and in batches.

(2) Exposure to 37° C. : $t_2 = 22{\cdot}5$ hours.

(3) Development at 29° C. till death.

The differences between calculation and observation lie in general within the limits of observation as common errors. Small deviations therein are caused by accidental variations of other environmental conditions. They can be observed as retardations in development (see section IV). The following Table 5 shows the effect of an alternation of temperatures with a calculated

Tab. 5. The duration of the different stages of *Prodenia littoralis* in alternating temperatures, + = death.

→At the optimum.

Stages.	Birth.	Mandibles visible.	Mandibles dark brown.	Egg becomes black.	Hatching.	I. moult.	II. moult.	III. moult.	IV. moult.	V. moult.	Praepupa.	Pupation.	Emergence.	Death.
Egg without any marks	25·3	25	25	25	25	25	25	25	25	25	25	25	25	25
Egg light with mandibles	10·9	10·9	10	10	10	10	10	10	10	10	10	10	10	10
Egg yellow with dark mandibles	6	5·4	5·2	5	5	5	5	5	5	5	5	5	5	5
Egg black	5·3	5·2	5·1	5	5	5	5	5	5	5	5	5	5	5
Larva I	44·9	42·9	41·1	39·9	39·1	39	39	39	39	39	39	39	39	39
Larva II	35·6	31·6	31·6	30·1	29·9	27	23	23	23	23	23	23	23	23
Larva III	62	54	50	50	49	43	40	40	40	40	40	40	40	40
Larva IV	96	64	58	55	53	49	38	35	33	33	33	33	33	33
Larva V	47+	111+	130+	139+	129	58	55	46	41	39	39	39	39	39
Larva VI	+	+	+	+	17+	127+	162+	112	87	78	64	64	64	64
Praepupa	+	+	+	+	+	+	+	*88+	32	25	20	20	20	20
Pupa	+	+	+	+	+	+	+	*0+	110+	134+	213+	262+	132	132
Adult	+	+	+	+	+	+	+	+	+	+	+	+	179+	503

At 36° C.←

* Dies at pupation.

example. The reaction of the insect is influenced from the moment when the change occurs, and by the developmental stage reached in the preceding period. Above the heavy zigzag line, the insect develops in the optimum (29° C.) and is brought into 36° at the limit of this line. At 36° C., development follows its course till death. The numbers represent the length of each developmental stage in hours. The table shows many phenomena well known in entomology and demonstrates, therefore, that the formulae are already useable approximations. The younger the insect is at the transfer to a temperature of 36° C., the greater is the injury in development that follows and, indeed, the more marked, the further development goes on. If the insect is reared entirely in 36° C., the larval stage IV takes 96 hours, transferred as newly hatched larva I, stage IV takes 53 hours, but transferred just moulted to larva IV, this stage takes only 35 hours. In this case, the length of this stage is practically the same as in the optimum, where it takes 33 hours. That is a result which is very important for the comparison of different published observations. If bred entirely in 36° C., the insect dies at larval stage V, which takes here only 47 hours. The later the insect is transferred as an egg into 36° C., the longer the larva V remains alive, up to a maximum of 139 hours. Transferred as newly hatched larva I, the insect develops to larva VI. The length of stage V is shortened again, but death occurs soon after moulting. The difficulty in moulting is just surmounted in this case. Now, again, the same phenomenon takes place at larva VI as before at an earlier stage. The later the larva is transferred, the shorter is the length of stage V and the longer the duration of larva VI. The same phenomena take place at each following stage. They could be illustrated in more detail, if the change of temperature took place between two moults.

It is evident how important it is to know the individual prehistory of an insect for each experiment, as the length of the several stages is very different according as the individuals are reared at the same temperature during their life, or as we collect the stages to be investigated from some culture in a room, greenhouse, or even out of doors. As it will be shown later on, these considerations hold true also for mortality, range of variation, and, in the same manner—as can be said already—for respiration, heart beat, and many other phenomena.

There is a conception mentioned by Martini that it is impossible to compare the developmental velocities of the different stages of an insect. But it is evident from the examples given above that it is absolutely necessary to compare the reactions of development in all stages, if really exact data are required. On the contrary, it must be considered not unobjectionable from a physiological point of view to regard each stage, so to speak, as a self-dependent individual. Such a comparison was impracticable, certainly, before there was a possibility of calculating the temporal course of development at any temperature and of defining the physiological state of the organism, as is now possible. The developmental velocity, as the term has been used hitherto, like the velocity of a uniform motion $\left(v = \frac{s}{t}\right)$, has had only an average value. But, if we consider the development as a retarded motion, the method is given to follow the reactions of the different stages for the total life of the individual and to compare them.

The derived formulae hold good, as I have already mentioned above, for a special group of temperatures. I have shown (1930) with *Prodenia* that at temperatures, where the duration of life takes a longer time than at the optimum and already in temperatures which are approaching them, *e.g.* at 33° C. for *Prodenia*, the present formulae are not sufficient. Thus, it was necessary to expand them. The first formula, which has been used for v for a long time, was

$$s = v \, . \, t \text{ (uniform motion).}$$

Substituting P instead of v we have expanded the formula to

$$s = Pt - \tfrac{1}{2}gt^2 \text{ (uniformly retarded motion),}$$

in which an integration constant K must be added. At first, we have put $K = 0$. But in this other group of temperatures, we must go back to this K, which is not a real constant, but a collective number. I have derived, then, for *Prodenia* in 33° C. the formula

$$s = Pt - \tfrac{1}{2}gt^2 + ht - K_1$$

which gives, as I have shown (1930), useful results for this group of temperatures within the vital zone. The values of h and K in this equation are to be seen in Table 3 in the column for the quadratic equation. The cubic equation, which is common in physics,

$$s = Pt - \tfrac{1}{2}gt^2 + \tfrac{1}{6}ht^3 - C \text{ (non-uniformly retarded motion),}$$

is a still better approximation and gives better results in relation to the observed data for *Prodenia*; but, as the calculated hours lie within the limits of the times of observation, the equation with ht may be regarded as sufficient, since the methods of computation are more convenient. The values of h and C in this cubic equation may be seen in Table 3. Details were published in 1930. But the value C in Table 3 is again no real constant, but also a collective number, which varies with the time. That means, that this method leads us, at last, to a mathematical series:

$$s = Pt - \frac{gt^2}{2!} + \frac{ht^3}{3!} - \frac{h't^4}{4!} + \frac{h''t^5}{5!} - \ldots\ldots\ldots$$

The formula of the sum will probably be an exponential formula if we remember that, *e.g.*,

$$1 - e^{-t} = t - \frac{t^2}{2\,!} + \frac{t^3}{3\,!} - \frac{t^4}{4\,!} + \frac{t^5}{5\,!} - \dots\dots\dots$$

In the series for s_1 we can see, that the first term (Pt) was the basis for the average velocity $\left(v = \frac{s}{t}\right)$, as this expression has generally been used hitherto. Subsequently, we have added the second term for the first approximation ($Pt - \frac{1}{2}gt^2$), then, the third one and so on. Thus, the given derivation is absolutely logical. At present, our formulae are only approximations. It must be the problem of investigations of the future to find out the exact criterion of this series and of the final sum. At present, it is enough that it is possible in a defined group of temperatures to characterise the temporal course of development only by the first terms of this series, if we use as a basis the division of the total life-cycle from birth to death in a 100 units. The number of units that must be given to each biological phenomenon (hatching, moults, pupation, emergence, etc.) is determined by the character of the formula, which is valid for all temperatures, but it must be emphasised that our new developmental unit itself does not depend upon the respective form of the equation.

After that, it will also be possible to understand better the many different observations that have been made by authors on the different stages without special knowledge of the temporal course of development at the different temperatures. To-day, it may seem as if there is a contradiction in some results. How contradictory and confusing the particular results are is shown distinctively in the recent works of Friederichs and Uvarov, *e.g.* in the zone of temperatures above the optimum, where the development of the young stages takes less time, there occurs a shortening, if this temperature alternates with a lower one; but at temperatures a little higher, retardation takes place. The same holds true in low temperatures, where there are many more contradictions. But I do not believe, that they are, in truth, real contradictions. The term stimulation is in reality a name only for the phenomenon itself, and it describes the fact of a shortening in relation to another condition, but gives no explanation. The real effect of alternating temperatures is so complicated (even more so when combined with humidity, food, etc.) that it is urgently necessary to find a point from which all phenomena can be considered comparatively. There will be no objection, if we regard the absolute optimum, *i.e.* the combination of all optimal conditions, as such a point. However, this optimum for the different biological phenomena must be defined exactly.

It must be added that a characterisation of the effect of temperatures by mean temperatures is not quite correct, since the accelerating and retarding effect of two respective temperatures is not equivalent. In the formulae mentioned, the constant g can be considered an indication of this effect. The mean value of these retardation constants gives us the true effective biological mean temperature. If we put, *e.g.*, *Prodenia* daily for 8 hours into 29° C. and for 16 hours into 37° C., then, the mean temperature in degrees Celsius would be 34·4° C. The respective mean g — value is 0·0007304, which indicates (see Table 3) an effective biological mean temperature of 36·5° C. The importance of this method in recording mean temperatures is evident. The same holds true for low temperatures as well as if a temperature lies on the ascending or descending branch of the curve for the duration of life. There is no doubt that a clear picture of all these complicated relations can be obtained, if the temporal course of development at the different temperatures and the biological effect of the time of exposure has been found out, as I have tried to do in the case of the developmental equations as a first approximation. It is not yet possible to separate and to elucidate all observations about single phenomena, but we shall be able to derive from the curve of the duration of life and the death points all that will happen at each temperature and each alternation of temperatures, when we have found a formula valid for the course of development in all temperatures. This possibility of forecasting is the aim that general ecology and epidemiology hope to reach. To-day, the main point of investigations must be the experimental work systematically carried out on the total individual life-cycle.

III. MORTALITY.

The results described above were related on the one hand to the investigations that preceded my travels and were the reason for undertaking them, and on the other hand to the observations made in Egypt on *Prodenia littoralis*. These observations had elucidated the importance of the developmental optimum for the individual course of development. The question was, by which phenomena could the optimum for a population be characterised. Such an optimum, which has been called the vital optimum, must be defined by the rate of mortality and the range of variation, which are also important for the principles of general ecology and epidemiology. Therefore, a special investigation on the reaction of a population under conditions optimal for the individual development was necessary, since, in the literature, the vital optimum of a population has been separated in the scale of temperatures from the developmental optimum of an individual. We have already discussed the latter, and have seen that the minimum of the curve for a partial development is not the optimum for the total life-cycle. But for the most part such a minimum of the length of development has been defined as the developmental optimum for this respective stage. Such an optimum always lies of course at a relatively high temperature, but the vital optimum should lie at a relatively low temperature. The difference between both should determine the distribution and the outbreak of insects in a given climate. The definitions given for the vital optimum are somewhat different. There are four. Nos. 1–3 are defined by Bodenheimer, No. 4 by Blunck.

(1) The vital optimum is that temperature at which the highest number of individuals of a species live the longest time.

(2) The vital optimum is that combination of temperature and humidity in which, other conditions being equal, the individuals of an insect species reach a maximum duration of life.

(3) The vital optimum is that in which the highest number of individuals develop to adults.

(4) The vital optimum is that temperature in which the relatively highest number of individuals complete their life-cycle normally.

It is easy to see that two biological phenomena are involved in these definitions: the greatest duration of life and the greatest number of individuals (in other words the lowest mortality). Both should characterise the vital optimum, *e.g.* the vital optimum of tropical insects should be so far from the developmental optimum as to be at quite a low temperature. According to this theory, tropical insects should show a high mortality in a combination of temperature and humidity that affects a quick development. It must be mentioned that the foundation of the term vital optimum is based on the fact, that *e.g.*, adults of the cotton seed bug *Oxycarenus hyalinipennis* during their "quiescent" period die, *e.g.*, at constant 90% relative humidity after 200 hours' exposure at 40° C. 100%, at 35° C. 45%, at 30° C. 47%, at 25° C. 12%, at mean 17° C. about 2·5%, at 11° C. 2%. But we must remember that each biological phenomenon is much retarded at low temperatures and also that death occurs much later than at higher temperatures. Therefore, these 200 hours' exposure at low temperatures with a low mortality do not indicate anything concerning the "vital" optimum. From this fact alone (and there are also others) it follows that the derivation of a vital optimum from such relatively short periods of exposure is physiologically not without objections.

In Ceylon I reared tropical insects of different groups and carefully eliminated so far as possible each factor that could not be checked. Thus was isolated the pure influence of the climatic combination of temperature and humidity, which should be responsible for the required mortality according to the theory. With Lepidoptera, I obtained with *Attacus ricini* 337 pupae from 340 eggs. Two caterpillars of stage I died immediately after hatching owing to my inexperience, 1 caterpillar of stage IV died from unknown causes, *i.e.* a true mortality of 0·3%. With *Arcilasisa* (*Tiracola*) *plagiata* I bred 250 individuals without any mortality from egg to larva of the V and VI stage. With *Syntomis passalis* all the caterpillars hatched from two egg-masses, and 168 individuals developed to stage III without any mortality. Only one caterpillar died by accident. I was obliged to close these experiments when the caterpillars were at these stages, but there is no doubt that they can be reared further without mortality.

I made extensive experiments with 879 individuals of the mustard-bug *Bagrada picta* (PENTATOMIDAE). The rearing of this insect is technically not very easy, because the excrement is in the form of liquid drops in which the larvae are frequently entangled. But, in well-kept and not overcrowded populations, it was possible, by covering with filter-paper the inside of the lamp-chimneys used, to rear 100% to adults. The same result was obtained with the tropical bed-bug *Cimex rotundatus* (and later also with *C. lectularius*), if I fed the bugs every day in open glass tubes on the human skin without touching them with a brush. Also with the eye-fly *Siphunculina funicola* 98·8% of the eggs develop in some egg-masses to the pupal stage. Details of this were published in 1931. It might seem as if the number of individuals in these experiments is small, but it must be remembered that no selection was made. The single cultures were reared very carefully, and such work takes much time. The greater the number of individuals is, the less we can ensure optimum conditions as I have observed on these *Bagrada*-bugs, *e.g.*, there died at a density of population of 182 individuals 60%; of 98, 31%; of 40 and less 0%.

These results with *Cimex rotundatus* are interesting. I had adults and larvae of stage V collected by native children in their houses, the bugs showing some injury in many cases. The following Table 6 gives the results.

In catching them, the children probably poured water over them, I was told, and had also pressed them. The first eggs laid by the newly caught adults showed, therefore, a mortality of 100% in rearing them. Most of them died at the egg stage (A_1). Soon after being caught, a certain number of adults died, the offspring of the rest also showed a mortality of 100%, but most of these individuals did not die at the egg-stage, but died as larva I after the first feed (A_2). After a large number of these adults had died, the survivors laid eggs (B_1), which developed without any egg mortality. The maximum mortality occurs at the first larval stage after the first meal and at the second stage. The total mortality during the pre-imaginal development decreases to 52%. A single observation (B_2) showed only a mortality of 14%. In a mixed culture (A + B) the deaths are distributed homogeneously over all young stages with a mortality of 44%. Another series of bugs were caught as larvae V and were reared to adults in the laboratory. The first adults to emerge laid eggs that showed no egg mortality. The mortality began only at the first larval stage with a maximum after the first meal. The total pre-imaginal mortality was 35%. The rest of larvae V had developed to adults with a certain retardation which indicates a physiological injury. The offspring showed, therefore, a relatively high egg mortality and a total mortality of 55%. It must be mentioned that for feeding purposes the bugs were put into wooden boxes or special glass tubes with silk gauze, a method that causes a certain mortality itself (by brushing out the bugs, etc.), as may be seen in Table 6 at D_1. The bugs bred in a 27° C.-incubator at humidity of 75% (over moistened NaCl) do not show any pre-imaginal mortality, if they are fed in open tubes on the human skin (D_3). That means that there is also no innate high mortality at the developmental optimum.

Tab. 6. Deaths at the developmental stages of *Cimex rotundatus* with regard to the parental generation.

Group.	Number of eggs.	Egg dead.	Dead at hatching.	I. Dead before feeding.	I. Dead after the first meal.	II. Dead.	III. Dead.	IV. Dead.	V. Dead.	Dead in %.	Notes.	
A_1	35	21	5	8		1				100	Offspring of adults just after catching them in houses.	
A_2	21	3	1	4	12	1				100	Offspring of adults after a part of them have died.	
A+B	25	3	2	1	2	3				44	Mixed offspring of A and B.	
B_1	121			7	34	18	3	1		52	Offspring of adults later after many of them have died.	
B_2	14					1		1		14		
C_1	198			8	44	14	4			35	Offspring of the first emerged adults.	Offspring of adults caught as larvae V in houses.
C_2	133	9	14	17	27	5	1			55	Offspring of adults with a retardation in development.	
D_1	38				3	1	1		1	16	Feeding in wooden boxes.	Offspring of the following generations at 27° C. and 75% rel. humidity in incubators.
D_2	31					1				3	Not yet quite experienced in feeding on human skin.	
D_3	138									0	Quite experienced in feeding on human skin.	

Similar results were obtained with eye-flies. The eggs laid by flies of different catches showed in many cases a great mortality, but in others much less. It was impossible to analyse the facts so exactly as could be done with bed-bugs, since the natural breeding places of these flies are not known. It may be that the mortality is also caused by phenomena of age of the ovipositing adults, since the eggs are probably infertile. These experiments show how cautious we must be in rating results of wild populations and how important it is to know the prehistory not only of the individuals, but also of the parental generations.

Since unselected wild populations have been observed in all cases and several species of different groups of insects have been investigated, the experiments show that the lowest mortality of tropical insects lies at the same combination of temperature and humidity that also induces a quick development. In other words, that temperature in which the greatest number of individuals of a population normally completes their life-cycle (= vital optimum) is the same as that in which the individuals complete their total life-cycle in the shortest time (= developmental optimum). It follows from the results that the vital optimum cannot be defined as longest duration of life, as has been done in the above-mentioned definitions 1 and 2. On the contrary, the longest duration of life, *i.e.* the left maximum of the curve in fig. 7, is, in fact, closely related to the term developmental zero point in its old sense. Therefore, the contiguous position of these two points is to be understood simply by the fact, that the same biological phenomenon, *i.e.* long life at low temperatures, has been denoted by two different names: vital optimum and developmental zero point. The application of these terms has, naturally, resulted in much confusion and dissension in the literature. The distance of the temperature with a maximum duration of life from the developmental optimum for the total life-cycle which is, as we have seen, also a vital optimum in the correct sense of the word, means the same as the old ecological terms steno- and eury-thermism.

IV. The Range of Variation.

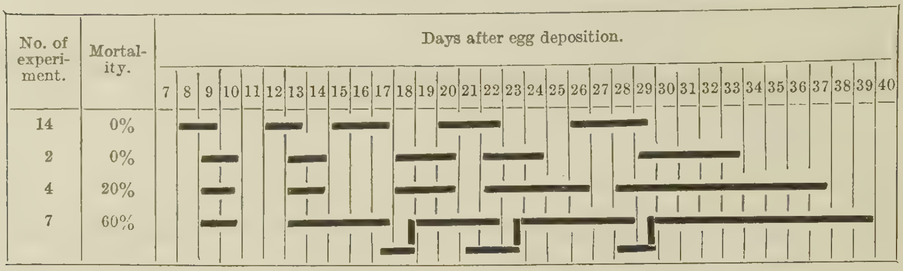
Simultaneously with the experiments on mortality, the range of variation was investigated, and remarkable results were obtained that are closely related to the problem of the length of development and of the mortality at different environmental conditions. Table 7 shows the range of variation in the moults of *Attacus ricini* and *Arcilasisa plagiata*. We see that all moults of *Attacus* occur within a range of 18 hours, *i.e.* practically within the same time. The same holds good for *Arcilasisa* with four moults. The fifth moult takes place in 50% of the individuals in the same range, and most of the rest also moult with only a little retardation, within 15 hours. Only 2·4% show a greater retardation, which affects, therefore, a total range of variation of 29 hours. The cause of this is a little too great a density in the broods of the grown larvae. This means that the lowest mortality is combined with a small range of variation in the zone of the developmental optimum.

Tab. 7. The total pre-imaginal mortality and the range of variation at the different moults of two Lepidoptera in Ceylon.

Species.	Mortality.	1st moult.	2nd moult.	3rd moult.	4th moult.	5th moult.
Attacus ricini .	0·3%	18	18	18	18	—
Arcilasisa plagiata .	0%	8–12	10	12	10	12 (50%) 15 (47·6%) 29 (2·4%)

In Table 8 the black lines show how, with *Bagrada picta*, the range of variation increases in more unfavourable environmental conditions. No. 14 belongs to a relatively good group of experiments, in which I profited by former experience. The mortality was here 0%. The range of variation was at the first and second moult 2 days, with the rest 3 days and 4 days at the last moult. The eggs were laid within 24 hours in all experiments. In experiment No. 2, which was at the beginning of the series, the mortality was also 0%, but the general conditions were more unfavourable than in No. 14, since I was still unfamiliar with the species. The beginning of all moults was later, in the first two moults by one day, with the rest by several days. The range of variation was the same at

Tab. 8. The total pre-imaginal mortality and the range of variation in the moults of *Bagrada picta* under different conditions.



four moults as in No. 14, at the last moult greater by one day. The more unfavourable the conditions are, the greater is the range of variation and also the mortality. The range of variation increases the more development follows its course. Thus in No. 4 (with a mortality of 20%) it was already greater at the fourth moult by 2 days and at the fifth moult by 6 days than in No. 14. In the very overcrowded culture No. 7, the second moult already extended over 5 days, the third over 6 days, the fourth over 8 days, the last over 12 days. By this great retardation in moulting the periods overlap in No. 7. In the same direction, the maximum number of moulted individuals is displaced to a later day, as the following table shows. The greatest number of moulted individuals was observed in No. 14 and No. 2 on the first day of moulting; in No. 4 the number of skins was much less at the first day and equal to that of the second day. In No. 7 the maximum was on the third day. It is interesting to see that in No. 2 the number of moulted individuals on the first day was greater than in No. 14. This means that the retardation is not equally great with all individuals, since a part of them (8%) was not retarded by a whole day. In No. 4 and more so in No. 7 a relatively greater number of individuals is influenced by the more unfavourable conditions, a fact that is moreover combined with an increasing mortality. Such a different kind of reaction in the several individuals of a population is worthy of more careful study. A method is here given to solve the problem of the individuality and constitution, since such a reaction is easy to record. It is important that the displacement of the moults both temporarily and with regard to the number of moulted individuals, corresponds to an increasing mortality. It must be added, that, in general, the individuals with a retarded development die at an earlier stage.

Tab. 9. The total pre-imaginal mortality and the range of variation at the second moult of *Bagrada picta* in per cent. of moulted individuals.

Experiment No.	Mortality.	Days after birth.					
		12.	13.	14.	15.	16.	17.
14	0%	82	18				
2	0%		90	10			
4	20%		50	50			
7	60%		3·4	22·5	41·5	31·5	1·1

It follows from these investigations that the first reaction of a population to unfavourable conditions is the temporary retardation of the developmental phenomena. The second reaction is the mortality, which takes place at a definite rate of illness. There is an absolute parallelism between the length of development and the occurrence of death of the individuals on the one hand and the range of variation and the mortality of the population on the other.

By studying all the phenomena, it may be possible in the future to measure the physiological constitution of any population by recording only the reactions of the given stages, and then, by calculation, to predict the distribution and possible outbreaks of an insect.

V. GENERAL CONCLUSIONS.

It follows from the preceding remarks that four facts determine the number of insects in a given area and the developmental stage in each season :

(1) The length of development and the duration of life, *i.e.* the time required for the total life-cycle including birth and death. The periods determine the seasonal distribution and the number of generations.

(2) The death rate, *i.e.* the number of dead individuals in the time *t*.

(3) The total number of eggs or, in other words, the number of offspring after one year, if all eggs had developed and propagated, *i.e.* the developmental potential.

(4) The range of variation, which causes the overlapping of the stages and generations.

A special problem in ecological and epidemiological research is the mortality. This term is not clearly defined. At first, we must mention the axiomatic fact that all individuals must die, *i.e.* that, in all cases, the mortality is 100%. To speak of a mortality which limits the developmental potential has a meaning only if some other determinations concerning death are given. That may be the time at which death occurs, but we have seen that the duration of life differs very much. The fact that in a relatively short time only a few individuals have died at lower temperature, says nothing but that, *e.g.*, the development slackens and death takes place relatively later, as is demonstrated by the maximum on the left hand side of the curve of the duration of life. A mortality limiting the developmental potential must be defined by the developmental stage and means, then, the number of individuals which, in a given environment, die before maturity takes place. However, as recent experiments in my laboratory show, injuries effected in youth by non-optimum environmental conditions become injurious as an after-effect in adult life and are responsible for a reduced egg-production and even for death, which is, in this case, not physiological death. Therefore, physiologically considered, mortality would be the number of individuals that die by a pre-senile death. But we do not know much about adult life in different environmental conditions, and investigations, which must exclude the individual injuries and those of former generations, *e.g.* injury to the immature eggs in the ovaries, require much time and are technically difficult, more especially those dealing with old age. On the other hand, it would not be helpful to take as a criterion the number of those individuals that die without having been able to reproduce, because many adults are, under some conditions, nearly sterile and lay only a small number of eggs. We find all integrates. Therefore, for practical purposes, we are obliged to take a definite limit and to define as mortality only the number of individuals that die at a pre-imaginal stage during development from birth to emergence. Ecologically, it is unimportant when this death occurs. The main point is that these individuals do not propagate. For special epidemiology, the death rate, *i.e.* the dying of a population as a function of time, is important, if, *e.g.*, some caterpillar stage becomes particularly injurious, and if we wish to know the number of individuals and the time at which they will reach a given stage.

According to the definition, the mortality at all temperatures outside the vital zone of fig. 7 amounts, in all cases, to 100%. Of course, the limits of the 100% mortality are displaced, if temperatures alternate or if separate stages only are investigated, in the same way as the curves of the length of development and of the remaining life expectation are displaced and the rate of development, especially the final value of development (= death point) is changed. The rate of mortality is furthermore much influenced by former conditions and depends upon the rate of mortality that has already taken place at earlier stages.

Observations on the mortality of tropical insects show that there is no especially high mortality among them; on the contrary, the combination of temperature and humidity which affects a rapid development, is also the zone of the lowest mortality, *i.e.* a vital optimum in the true sense of the word. This zone lies at a relatively high temperature just as the optima of the other biological phenomena, egg-production, metabolism, heart-beat, activity, etc. The same holds good, as the researches point out, for the range of variation, which is small in the same zone. We conclude then that all biological qualities that we consider the best for a species lie in the same region of temperature, which we must accordingly define as the biological optimum. The absolute optimum is the combination of all optimum environment factors and means that temperature at which, at optimal humidity, the best nourishment, a sufficient supply of oxygen, light, etc., is characterised for the respective insect species by the following phenomena :—

(1) Completing the total life-cycle until physiological death.
(2) Completing the total life-cycle in the shortest possible time.
(3) Highest production of fertile eggs.
(4) Uniformly small range of variation at all developmental stages.
(5) No mortality, *i.e.* no death which is not caused by physiological senility, or, for practical purposes, no death at a pre-imaginal stage.

This means, for the individual, that it shows the highest possible biological efficiency of the species, and for the population that the greatest number of insects show this highest individual efficiency.

Up to the present it is not possible to give an exact affirmation as to whether the same temperature is the general optimum for all phenomena or not, because close to the absolute optimum the effect of small deviations becomes evident only at old age. But the temperature zone that contains the optima for the different phenomena is certainly very narrow and probably only one point. Deviations from the absolute optimum, either in an experiment or in nature, affect a reaction in all phenomena, however short the time of exposure may be. At first, the range of variation increases. We observe retardations, *e.g.*, at the different moultings, which are not the same with all individuals; but it is not yet possible to say anything positively about the different constitution of the individuals. By such different reactions, the importance of mean values is diminished, even almost misleading. With somewhat greater injury the more sensitive individuals die. The further the deviation from the optimum (*e.g.* at a low temperature) the greater is the range of variation. But at the true absolute optimum, all individuals (of a pure physiological line, of course excluding all injuries to the parental generations) have nearly the same constitution. It may therefore be stated that the reaction of a species in its absolute optimum gives a fundamental value for comparison with all other data at different conditions.

Definite conclusions as to the ecological distribution of species and their outbreaks may yet be anticipated. The main need at present is experimental work, especially in respect of the total course of the individual life either under exact laboratory conditions or those in the field. The first method is more exact. It also leaves the investigator free to study whichever environmental factor he, at first, considers more important. The field research requires a long time and gives only empirical norms, which are based upon experiences in a very complicated environment. This does not, however, exclude the possibility of utilising both methods and they would stimulate each other.

The ecological distribution and the outbreak of insects depends upon the physiological reaction to the environment and is defined by the position of the optimum and by the steepness or flatness of the curves of the duration of life and of the death points; in other words, by the stenothermism or eurythermism (or, more generally, by the stenoecism or euryoecism) of the species. With these terms we connect the range of variation, mortality, and number of eggs in their dependence upon the environment. In the case of the cotton-worm, *Prodenia littoralis*, the outbreak on the trefoil and cotton fields of Lower Egypt begins every year in the spring and culminates after several generations at the end of June or the beginning of July. At the end of July, the number of insects decreases suddenly without the help of parasites. The beginning and end of this outbreak, which is, therefore, a very simple case, depends only upon temperature. The change of the second climatic main factor, the humidity, is eliminated in Egypt, since the weather is absolutely rainless, and regular artificial irrigation takes its place. The outbreak of *Prodenia* proceeds, if the weather conditions successively approximate the optimum of the species, and collapses, if the high temperatures of July in daytime exceed the optimum. An outbreak of insects in the tropics occurs suddenly, if the environment conditions approximate the absolute optimum, which happens relatively easily, in the almost uniform climate, for a short time at favourable places, *e.g.* during the monsoon. Then nearly all eggs of a population develop, since development goes on in a comparatively short time; *i.e.* an outbreak takes place in one generation. In temperate climates, some years with conditions that are favourable to the insect concerned must follow each other. But, fundamentally, an outbreak of insects is, in all cases, chiefly a physiological reaction to environment. The limitation of the increase in the tropics is probably caused by stenoecism in so far as parasites and diseases are not responsible.

SUMMARY.

(1) Attempts to find out the relations between temperature and length of development, duration of life, and also respiration, growth, heart-beat, etc., must be theoretically well founded and must agree with experiments. It has been demonstrated that theoretically the exponential curve is well based on the general law of mass action. However, the simple exponential curve does not agree with all observed data or with the biological situation. But the resultant of two crossing exponential curves described as a catenary curve is smoothed to the observed points and agrees without exception with the biological situation. All biological formulae referring to exponential curves are collected in the " exponential law " as a superior biological law. A simple method of calculating the constant a of the catenary curve has been given.

(2) The effect of temperature and the course of development has been investigated by experimental researches with the cotton-worm *Prodenia littoralis* in Egypt at 22° C., 29° – 40° (besides that at 0° and – 18° C.). There are two groups of experiments: (*a*) the continual influence of constant temperatures on the total life-cycle; (*b*) the temporary influence of injurious temperatures with successive transfers of the insects into their optimum (29° C.). By observing the course of development with the different phases I have pointed out that the current view regarding this process is not quite correct and that the developmental velocity (v), which hitherto we have defined as a reciprocal value of the time (t), cannot be regarded as a constant. The course of development cannot be compared with a uniform motion $\left(v = \frac{s}{t}\right)$, but must be considered a retarded one, where the velocity of development has an initial value P, which is biologically defined as developmental power at birth. The velocity v decreases when the development follows its course and equals zero at the death point. The path of motion (s), which is biologically the length on the developmental path and has been equated hitherto as a constant to any number (generally 1), must have then a different value at each temperature. This developmental path, which can be considered as a numerical scale for the development itself, can be calculated, if we put—according to the equation for a retarded motion in physics—$v = P - gt$ and $s = Pt - \frac{1}{2}gt^2$. Now we can define each developmental stage by a numerical value of s, if we give the value 0 to birth and the value 100 to physiological death. The numerical values of s can be computed by the equation, if we put the observed time (t) for each developmental stage into the equation. By dividing the developmental path from birth to physiological death into 100 equal parts, we get a new developmental unit, which we call "developmental degree" and which is not a period of time, but a quantity with its own dimension.

(3) The calculated values of t show a good conformity to the observed data at constant as well as at alternating temperatures. However, the course of development like $s = Pt - \frac{1}{2}gt^2$ holds good for *Prodenia* at a certain group of temperatures only. Within the vital zone, we must expand the formula by new terms to an equation for a non-uniformly retarded motion. Such a formula conforms then to the observed data with *Prodenia.* This method of expanding leads us, at last, to a mathematical series, which has probably an exponential formula as its sum.

(4) With the method just outlined, one may calculate the effect of environmental factors and the course of insect development at alternating conditions as in an insect outbreak. The experiments verify especially the fact that biologically extreme factors prevent an outbreak of insects. In no respect do averages of temperatures give an exact determination for the outbreak and the ecological distribution of insects, but only the mean effective biological value of the temperatures can be used.

(5) The developmental velocity gives a measure for the internal physiological constitution, which has been changed by some external influences. This idea is supported by observing the morphological marks of the caterpillars at different stages of *Prodenia* and their susceptibility to diseases (polyhedra). By the definite value of the developmental velocity the possibility is given of elucidating, by a causal explanation, many observed biological phenomena, *e.g.* forced pupation, variable resistance of the different stages to climatic extremes and against poisons, retardations of moults and the irregularities at maturity, egg-laying, and old age of the adults.

(6) The critical points of heat and cold are not biologically realised as origins. Only the developmental optimum is a biological fixed point in the scale of temperatures. This optimum is characterised as that temperature that shows in the shortest time the most complete development up to old age. A real stoppage in development, *e.g.* at a so-called developmental zero point, does not take place at any temperature. Each short exposure to non-optimal influences causes some damage to the growing organism.

(7) Non-optimal degrees of humidity, food conditions, etc., and also poisons have the same biological effect as non-optimal temperatures and are also responsible for a shortening of the length on the path of development and for an increase of the time-duration, except the last stage, which is shortened, before death occurs.

(8) In Ceylon, the mortality and the range of variation during development has been investigated at that combination of temperature and humidity which is a developmental optimum for the insects in question. By means of breeding experiments under the best conditions possible it has been shown in various orders of insects (Lepidoptera, Hemiptera, Diptera) that tropical insects do not have an unusually high innate mortality in a temperature-humidity combination which produces a quick succession of generations. Rather, the developmental optimum is likewise the vital optimum, in which the largest number of animals develops without pre-imaginal mortality. The term " vital optimum," if defined as the longest duration of life, is closely related to the developmental zero point, so that its distance from the developmental optimum means the same as the old terms steno- or eury-thermism.

(9) The explanation of the poverty of individuals and the richness in species in the tropics must be sought on other grounds than a high innate pre-imaginal mortality. The causes underlying ecological distribution and outbreak of insects must be looked for in the steno- or eury-oecism towards some environmental factor. Animals that are stenoecic to any factor will always show a relatively small area of distribution and will exhibit rarely the capacity for producing outbreaks. Very small climatic variations on stenoecic animals will have the same ecological effect as larger ones on euryoecic organisms. Thus, the relation of insects to climate is qualitatively similar in all ecological groups.

(10) It has been demonstrated that we can only use the term optimum if the total life-cycle has been investigated; *e.g.* the most rapid development of a young stage does not agree with the highest possible biological efficiency of the individual in its total life-cycle. The highest possible production of fertile eggs and death by physiological senility is the criterion for the highest possible efficiency of the individual. If the greatest number of individuals show their highest biological efficiency, then the population as a whole also has its greatest efficiency. Special optima for the different developmental stages cannot be exactly defined. The definition of such a point as maximum or minimum has given rise to many misunderstandings in the literature.

(11) The true biological optimum of a species or a physiological race is a fixed point for all developmental stages and for all observed phenomena and lies probably at the same temperature, but certainly in a narrow zone. This optimum, which is simultaneously a developmental and a vital optimum, is defined for an ideal case in section V. The combination of all optimal factors is called the absolute optimum. Each deviation, however short, of one component affects an increase in the range of variation, and death occurs at an earlier stage and not by senility.

(12) The outbreaks of insects in the tropics generally take place suddenly,

if within one generation at favourable conditions nearly all eggs of a population develop. In Egypt, the outbreak of *Prodenia littoralis* goes on for several generations within one season. In temperate climates the outbreak needs several years with relatively favourable weather conditions. But in all cases, an outbreak depends to a considerable extent upon the physiological reaction of the individuals to the environment.

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A CONTRIBUTION TO THE STUDY OF THE GENERA *EPHESTIA*, GN. (INCLUDING *STRYMAX*, DYAR), AND *PLODIA*, GN. (LEPIDOPTERA, PHYCITIDAE), WITH NOTES ON PARASITES OF THE LARVAE *

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[Read 1st June, 1932.]

With Plates V–XII.

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Introduction and Acknowledgements.

The caterpillars of several species of the small Phycitid moths of the genera *Ephestia* and *Plodia* have, for the last fifty years, been serious pests of various stored food products, especially cereals, dried fruits, nuts and cacao. In recent years the storage of large quantities of these products in warehouses supplying the ever-increasing concentrations of the human population has made the ravages of these insects both more important and more noticeable. At the same time increased facilities for transport have not only directly enlarged the range of the species, but have opened up new countries as a source of various products and so still further spread the pests. Several species of these moths are now found all over the world and others are likely to become cosmopolitan in the future.

In view of the differences in habit and in adaptability to new conditions nearly always observed in insect-species, it is evidently important (1) to be able to recognise with certainty each species of such a genus as *Ephestia*. A list (2) of the various products on which the larvae have been observed to feed is valuable as an indication of the direction in which further damage is likely. Where control measures have become necessary, it is usually helpful to know, if possible, the original home (3) of the species, especially if the introduction of parasites is under consideration. Finally, the actual range (4) of the species at the present day must in part determine what measures, if any, are worth adopting to prevent further spread.

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The present paper is primarily a systematic study of the species, *i.e.* it endeavours to answer the questions raised by problem (1) of the preceding paragraph; incidentally, however, much information concerning problems (2), (3) and (4) has accumulated. This has been amplified by including a list of the known parasites and predators. The taxonomy of *Ephestia*, regarded as a purely entomological problem, has certain features of interest. Up to the present time about 60 species of *Ephestia* (including *Strymax*) and 2 of *Plodia* have been described. Hitherto the species have been differentiated almost entirely by their wing-pattern, slight differences in wing-venation and in the scale-tufts found on the wings of the males, being used to a less extent. Unfortunately the pattern is often obscure and highly variable, so that in the past misidentifications have been very frequent. In certain areas, *e.g.* Cyrenaica, several species assume a uniformly light buff tint, becoming thus almost unrecognisable on superficial examination and leading to the erection of several new names for well-known forms. Recently Curran (1926) showed that the males of the principal species affecting stored products could be very easily distinguished by the structure of the external male genitalia. In the present paper we have focussed our attention on the characters provided by the male and female genitalia. These characters have the advantage of being relatively stable, while the specific differences are usually of considerable magnitude. The chief material for our study has been the extensive collection in the British Museum, where the expert knowledge and generous aid of Mr. W. H. T. Tams have been placed at our disposal. Mr. Karl Heinrich of the U.S. National Museum has also been kind enough to arrange a loan of some of the specimens under his care and to answer our inquiries as to American species. Signor Conte Emilio Turati of Milan rendered us very essential aid by the loan of specimens from his collection, including types and paratypes of some of the species he has described himself. Mr. R. Attia sent us some interesting material from Egypt, the hitherto undescribed larva of *Ephestia calidella*, Gn., being particularly valuable. The work throughout has been carried on under the direction of Prof. J. W. Munro, whose advice and encouragement have been very valuable. To all these helpers we wish to give our thanks for their kind assistance.

There still remain a considerable number of species we have not been able to examine. Preliminary inquiries revealed that it would not, in any case, have been possible to examine the genitalia of the types of these species, and without such examination we should not have been able to add much information to that contained in Ragonot and Hampson's Monograph (1901). We do not doubt that eventually many of these will be found to be mere varieties of the better-known species. In certain cases, however, especially in the group centering round *Ephestia elutella*, Hb., there are almost certainly new species awaiting definition, which will not be possible till more material, especially long series collected in one locality, is available. We should like to take this opportunity to emphasise how worse than useless it is in a genus like *Ephestia* to describe new species on the basis of colour-pattern only, without reference to structural features, particularly the secondary sexual characters and the genitalia.

THE DEFINITION OF THE GENUS *EPHESTIA* AND ITS ALLIES.

It is not easy satisfactorily to distinguish the genus *Ephestia* from the most closely allied genera, since these themselves have not been very well defined.

Ragonot's key to the genera of the PHYCITINAE (in Ragonot and Hampson, 1901, pp. v–xiv) raises certain difficulties. The types designated for the genera are in some cases species not originally included and consequently the names applied to the genera, apart from their structural definition, require revision. The male and female genitalia have as yet scarcely been examined at all, though they would doubtless provide valuable generic characters.

We will therefore confine ourselves to giving diagnoses of *Ephestia* (with its subgenus *Strymax*) and of *Plodia*, taking care to describe such characters as Ragonot and Hampson's key show they regarded as important. Two of the genera closely allied to *Ephestia*, viz. *Ephestiodes* and *Eurythmia*, will certainly require redefinition. According to Ragonot and Hampson they are distinguished from *Ephestia* by the neuration of the hindwings in which Cu_{1b} (2) arises near the angle of the cell, and M_{2+3} and Cu_{1a} have a long stalk. The former character, however, is found in some species of the subgenus *Strymax*, while the latter occurs in *E. vapidella*, Mn., and *E. scotella*, Hmpsn. Probably the additional characters provided by the genitalia would make the separation of the genera more easy.

Ephestia, Guenée.

Ephestia, Guenée (1845*a*, p. 81), (1845*b*, p. 319).
[Misspellings: *Ephatia*, Alphéraky (1883); *Epheitia*, Johnson (1895*a*); *Ephectia*, Noel (1904); *Ephesia*, Craveri (1915).]
Phycis, Haworth (1811) in part, Zincken (1818) in part, Treitschke (1832) in part, Duponchel (1836) in part.
Phycita, Wood, W. (1837) in part, Westwood and Humphreys (1845) in part.
Tinea, Hübner (1796, pl. 24, fig. 163) in part, Stitz (1900).
Myelois, Zeller (1839*a* & *b*) in part, (1847*a* & *b*) in part, (1848*a*) in part, Lederer (1870) in part, Berce (1878) in part, Thompson (1887).
Myeolis, Leinig and Zeller (1846) in part.
Homoeosoma, Herrich-Schäffer (1849) in part.
Hyphantidium, Scott (1859) *nec* Staudinger and Rebel (1901, p. 23).
Euzophera, Staudinger (1859) in part, Millière (1875) in part, (1886) in part.
Pempelia, Walker (1863) in part.
Cadra, Walker (1864, p. 961). Monobasic, type [*C. defectella*, Walker (p. 962)] = *E. cautella*, Walker (1863).
Steganoptycha, von Heinemann (1865) in part.
Nephopteryx, Walker (1866, p. 1719) in part.
Salebria, Cotes and Swinhoe (1889, p. 675) in part.
Zophodia, Millière (1874) in part.
Unadilla, Hampson (1901) in part.

Type *E.* [*Tinea*] *elutella*, (Hübner, 1817), Herrich-Schäffer (1849) by the designation of Hulst (1890, p. 197).

Numerous authors, including Staudinger and Rebel (1901), have treated *Hyphantidium*, Scott, as a valid genus. The type of the genus (originally monotypic) is *H. sericarium*, Scott (1859), a species which is probably identical with *E. kühniella*, Z. The species referred by Staudinger and Rebel to *Hyphantidium* should correctly be placed in some other genus.

DIAGNOSIS OF **Ephestia,** GN.

Face (Pl. V, fig. 14) smooth without a projecting cone of scales or with a rather obtuse one; the chaetosema * from which a few long white bristles arise is visible as a scale-less

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* The chaetosema is an organ of unknown function found in the head of various families of the Lepidoptera. Its sporadic occurrence makes it of considerable classificatory value. Jordan (1923) first described it, and Eltringham (1925), who misspells the name "chaetosoma," has investigated its histological structure. Hering (1929) has extended its use in classification and figures it in a Pyralid (fig. 99, p. 40). Eltringham (1929) has reinvestigated its structure.

patch on the inner orbits a little way behind the base of the antennae (in the subgenus *Strymax* the chaetosema has a rosette of white scales); antennae of the male shortly ciliated, the base usually simple, but in *E. rubrimediella*, Hmpsn., excised before the apex of the first joint, or in the subgenus *Strymax* contracted a little beyond this point; galeae of the maxillae normally developed; maxillary palpi short, filiform; with the scales removed, they are seen to be three-segmented, the first segment somewhat thicker than the others, quadrate, the last two about three times as long as broad, the three together somewhat shorter than the apical segment of the labial palpi; labial palpi moderately long, ascending, clothed with appressed scales, terminal segment pointed; with the scales removed, the basal segment is seen to be rather thicker than the others, about two and a half times longer than broad, the second segment about twice as long as the first, the third nearly as long as the first.

The anterior tibiae with one median spur hidden by dense scales; the mid tibiae with two apical spurs, of which the outer is half as long as the inner; the hind tibiae ventrally with two spurs at the mid point and two at the apex, the inner spur being in each case the longer; the apical spurs are placed side by side.

Forewings (Pl. V, figs. 3*a*, 4*a*) with *Sc* meeting the costa at about its middle; R_1 obsolescent before reaching the costa, R_2 either reaching the costa or obsolescent just before it; R_3, R_4 and R_5 coincident; M_2 and M_3 coincident; one anal vein present; only veins M_1, M_{2+3}, Cu_{1a} and Cu_{1b} received by the termen, Cu_2 absent, vein 1*A* running out at a point very near the tornus. The base of the costa in the male sometimes deflected towards the under surface of the wing, enclosing a tuft of modified scales. Sometimes (*E. elutella*, Hb., group) a small tuft of yellowish modified scales is present near the base of the dorsum in the male.

Hindwings (Pl. V, figs. 2, 3*b*, 4*b*) with $Sc + R + M$ anastomosed to near the middle of the wing; $Sc + R_1$ arising near the apex of *Rs*, sometimes coincident with it (this character being not even of specific value); *R–M* either arising from M_1 very near the point of divergence of *M* from $Sc + R$ and running almost immediately into $Sc + R$, or completely coincident with the latter. M_{2+3} and Cu_{1a} always closely approximated in the neighbourhood of *M–Cu*, sometimes (*E. elutella*, Hb., group) shortly, or (*E. vapidella*, Mn., group) more extensively anastomosing. Cu_{1b} not approximated to Cu_{1a} except in some of the species of the subgenus *Strymax*. Veins Cu_{1a} and 2*A* each with a defined pecten (Pl. V, fig. 7) of hairs, often more developed in the male (Pl. V, fig. 6) than in the female, that on the anal vein also often preceded by a minute tuft of modified scales.

Markings (Pl. V, fig. 5): Forewings with three transverse lines; the first usually before the middle of the wing and dark in colour, bordered inwardly with paler scales; the second line beyond the middle, pale, outwardly margined with dark scales, sometimes inwardly also; the third line consisting of a series of dark spots just before the apex; on the disc of the wing a small dark spot, the orbicular; from about the middle of the dorsum a dark line often runs to a point close to, and below the orbicular; the discal end of this line is frequently darker than the rest of it, forming another dark spot, the claviform; in many cases there is further a dark shade running from the costal end of the second line towards the claviform; the dorsal margin of the wing is sometimes pale irrorated. (The first line is said to be oblique towards the base of the wing when its costal end is nearer the base of the wing than its dorsal; when oblique towards the apex of the wing it is directed reversely); hindwings whitish or greyish, rarely darker (*E. calonella*, Rag.), sometimes with a subterminal dark line; the cilia usually with a subbasal dark line.

On each side of the base of the ventral side of the abdomen is a tympanum (if the abdomen has been removed, the position of the tympanum indicates the ventral surface, a matter otherwise not always easy to determine in some females). In the male (Pl. VIII, figs. 37–43) the eighth tergite is usually modified; the sides of the tergite are largely membranous, but an apical area and a narrow central strip are more heavily chitinised;

at the sides anteriorly are narrow chitinised strips from which arise tufts of modified scales (except in *E. rubrimediella* and in the species of the subgenus *Strymax*); only a narrow anterior strip of the eighth sternite is chitinised. External genitalia. Male (Pls. VI and VII). Saccus with a median membranous area, sometimes covering more than half its width; valves with a strongly chitinised dorsal costa which is bifurcate anteriorly, and often emits a dorsal tooth at or before its posterior extremity; the basal margin reflexed forming a small sacculus; the surface of the valve just laterally and posteriorly to the sacculus usually with a small longitudinal fold; anellus usually exhibiting chitinised areas; two of these are ventral, and often fused across the median line; further they may be each posteriorly bilobed (*E. calidella*, Gn.); the other two are dorsal and appear, after the extraction of the aedeagus, as a pair of thickenings in the ventral wall of the tegumen; each of these dorsal thickenings sends out antero-laterally a process which is in close connection with the inner bifurcation of the costa; posteriorly they are sometimes fused together across the median line; in the species of the subgenus *Strymax*, in *E. rubrimediella* and apparently in *E. micaceella*, Rag., the ventral thickenings are much reduced and the dorsal thickenings are not developed; as a consequence paired thickenings of the tegumen itself become visible; these are continuous with the anterior margin of the tegumen, extending some way anteriorly to the bifurcation of the costa.

The gnathos is a small, median structure, sometimes emitting two lateral arms, and supported on a pair of struts; these struts run from the gnathos anteriorly, then curve sharply round and join the sides of the uncus; at the point where the struts curve they are in close contact with the lateral lobes of the tegumen; the anal tube emerges from the substance of the tegumen at a point immediately posterior to the gnathos; the ventral wall of the free part of the anal tube is sometimes thickened to form a subscaphium, which is often transversely striate; the uncus is broadly rounded and not subject to much modification; the tegumen laterally, at a point just dorsal to the articulation of the valve, is produced into a small lobe or (*E. cautella*, Wlk.) a finger-shaped process.

The aedeagus is a subcylindrical tube, sometimes expanded at the apex, rarely (*E. rubrimediella*, Hmpsn.) with a small apical tooth; the vesica has one large or (*E. rubrimediella*, Hmpsn.) two minute chitinised areas. Female (Pls. IX, X and XI). The eighth tergite sometimes evenly chitinised, sometimes with antero-lateral membranous areas, leaving a central, more chitinised portion, whose shape varies specifically; eighth sternite chitinised laterally, with a more or less extensive central membranous area; ovipositor of simple structure, elongate (*E. kühniella*, Z., etc.) or bluntly rounded (*E. cautella*, Wlk., etc.); bursa copulatrix large, the lamina dentata (signum of Pierce, 1914) usually replaced by 2–18 chitinised plates; the walls of the bursa sometimes also in part studded with small chitinised spots, bearing minute teeth projecting into the bursa; the ductus bursae either with similar tooth-bearing spots, sometimes spirally arranged, or with a long, chitinised plate; more rarely the whole ductus is evenly chitinised; the ostium bursae lies on the membrane between the seventh and eighth sternite; the seventh sternite is sometimes reflected above the ostium (*E. calidella*, Gn.) to form an operculum; two tufts of modified scales sometimes arise from narrow chitinised strips on each side of the ostium (*E. figulilella*, Gregs., etc.).

A SYSTEMATIC ACCOUNT OF THE SPECIES OF *EPHESTIA* AND *PLODIA*.

In the following account we deal primarily with species of which specimens were available for examination. In describing the ground-colour of the forewings, we have throughout employed the plates given by Ridgway (1912). The species examined are dealt with in an order exhibiting their approximate interrelationships. The characters on which the species can be grouped will be seen in the key (p. 210). Only the more important references to papers by earlier authors are included under the synonymy of the species. Further references will be found in the account of distribution and larval food-habits. The descriptions of species examined are followed by an alphabetical list which includes the names of all the species of the group and of their synonyms. We have maintained as distinct all species not seen by us, though on structural examination many might well prove to be only colour-varieties of well-known species. In the course of the present work we have considered all the species that authors have at one time or another ever referred to the genus *Ephestia*, but the catalogue only contains such specific names as are correctly referred to the genus. In one case, that of *E. scipionella*, Trti., we make an exception, since the correct generic position is not yet determined.

E. vapidella, Mn.

vapidella. 1857 : Mann, 171 (*Ephestia*). 1879 : Staudinger, 229. 1901 : Ragonot and Hampson, 303, pl. 35, fig. 15; Staudinger and Rebel, 16. 1910 : von Caradja, 120; Spuler, 203.
roxburgi. 1922 : Turati and Zanon, 164 (*Ephestia*). 1924 : Turati, 133.
E. vapidella was wrongly referred to *Cryptoblabes gnidiella*, Mill., by Millière (1886, p. 47).

Forewings : fuscous, basal quarter (more along the costa) and a broad dorsal streak, russet; moderately elongate, costa very slightly curved throughout; 1st line a little after the middle, a little oblique towards the base of the costa, straight in the dorsal half, sinuate towards the costa, narrow, whitish; 2nd about halfway between the first and the termen to which it is subparallel, nearly straight but slightly sinuate near the costa, white, margined inwardly with hardly darker scales; 3rd represented by a series of indistinct whitish spots; orbicular white, claviform absent; terminal cilia a pale grey with a darker subbasal line. Hindwings whitish, very narrowly margined with grey, cilia whitish, with a darker subbasal line. M_{2+3} and Cu_{1a} with a long stalk, about half the length of the free part of Cu_{1a}, enclosing a short fork. Exp. ♀ 12·5–17 mm.

Genitalia : ♀. (Pl. X, fig. 96.) Ovipositor elongate, rounded at apex, the struts about 4 times as long as the width of the 8th tergite, which is largely membranous, a narrow anterior margin and central strip more heavily chitinised, anteriorly with a narrow, V-shaped emargination; ductus bursae with a dense patch of small, rather elongate chitinised spots in the neighbourhood of the bursa; bursa (Pl. X, fig. 99) with no small chitinised spots, the lamina dentata with 4–5 rows of small teeth.

Specimens seen : JUGO-SLAVIA : 1 ♀, Croatia, 3 Sept. '49, Mann, Zell. coll.; CYRENAICA : 2 ♀♀, Bengasi, 18 June and 15 Nov. '22, coll. Turati. The above description is drawn up from one of the specimens from Cyrenaica; the other has the forewings mainly light pinkish cinnamon. The European specimen is much more grey, the forewings being light drab, but it is in bad condition. *E. vapidella* was described from Fiume and is also recorded from Sicily, Sardinia Beirut and Asia Minor.

E. scotella, Hmpsn.

scotella. 1900 : Hampson, 72 (*Ephestia*).

Forewings : elongate, costa nearly straight; brownish, but the specimen too worn to describe. Hindwings : dark grey, narrowly margined with darker, cilia concolorous. M_{2+3} and Cu_{1a} fused for a length almost equal to that of the fork, which is short. Exp. ♀ 14 mm.

Genitalia : ♀. (Pl. X, fig. 97.) Ovipositor rounded, about twice as long as broad, its struts about twice as long as the width of the 8th tergite, which is largely membranous, with the sides and a narrow anterior margin, emitting a broad, bilobed, central process, more chitinised; ductus bursae with a patch of minute chitinised spots in the neighbourhood of the bursa; bursa (Pl. X, fig. 95) with no minute chitinised spots in its wall, the lamina dentata (Pl. X, fig. 98) with six large and five minute teeth.

Specimens seen : CHRISTMAS ISLAND : 2 ♀♀, north part of island, Dec., '97 (*C. W. Andrews*). One of these ♀♀ (expanse 14 mm.) is the type which we have described above. The other ♀ (expanse 18 mm.) is also worn, but appears to have the basal half of the forewings paler than the apical half; it may belong to the same species.

E. calonella, Rag.

calonella. 1888 : Ragonot, 36. 1901 : Ragonot and Hampson, 281, pl. 35, fig. 24; Staudinger and Rebel, 15.

Ragonot described his species from Andalusia, Spain, the only locality hitherto recorded. The specimen we examined was presumably identified by Hampson and agrees fairly well with Ragonot's description though less well with his figure.

Forewings : pale ochraceous-buff; elongate, costa very slightly curved; lines brown, 1st rather before the middle, slightly curved, with its convexity outwards; 2nd straight, oblique towards the apex, placed rather nearer to the termen than to the 1st; 3rd consisting of a broad apical shade; orbicular and claviform distinct, separated from the 2nd line by about its width. Hindwings : dark grey, cilia paler with a distinct subbasal dark line. M_{2+3} and Cu_{1a} approximated at base, enclosing a long fork. Exp. ♀ 20 mm.

Genitalia : ♀. (Pl. XI, fig. 100.) Ovipositor, 8th tergite and their struts elongate; 8th tergite with an elongate-triangular, posterior membranous area; lamina dentata (Pl. XI, fig. 101) consisting of a single plate with two irregular rows each of about 6 teeth. (Ductus bursae not visible in this specimen.)

Specimen seen : We have been able to examine only one, a ♀, SPAIN : Vigo, 18–27 June '06 (*T. A. Chapman*), in the collection of the British Museum.

E. declivella, Z.

declivella. 1881 : Zeller, 244, pl. 12, fig. 47 (*Ephestia*). 1901 : Ragonot and Hampson, 303 1929 : Dyar, 17.
animosella. 1914 : Dyar, 345 (*Ephestia*).

Forewings : wood or hair brown, moderately elongate, costa distinctly curved throughout; 1st line strongly oblique, its costal end well before the middle, its dorsal end about at the middle, white; 2nd distinct, parallel to the termen, nearly straight but slightly curved inwards towards the costa, outwardly margined with purplish; 3rd indicated; stigmata no darker than the ground-colour but defined by a whitish diffusion. Hindwings : rather dark grey, margined with darker, cilia concolorous with a darker subbasal line. M_{2+3} and Cu_{1a} very shortly stalked, enclosing a moderately long fork. Exp. ♀ 11 mm.

Genitalia : ♀. (Pl. XI, fig. 107.) Ovipositor twice as long as broad, rather pointed, its struts about 1½ times as long as the width of the 8th tergite, which is chitinised anteriorly and posteriorly, with a broad transverse central strip more membranous; the dorsal wall of the ostium bursae produced beyond the 7th sternite, its posterior margin bisinuate; ductus bursae evenly but not heavily chitinised throughout, towards the ostium thrown into numerous longitudinal folds, of which a central pair define a raised median area; ductus connected with the bursa by a short, longitudinally folded section; bursa (Pl. XI, fig. 106) with no small chitinised spots in its wall, the lamina dentata consisting of a small plate with three rows of teeth, seven teeth in all.

Specimens seen: Colombia: 2 ♀♀, Honda (*Petersen*), Zeller Coll., British Museum; Panama: 1 ♀, Trinidad River, March '12 (*A. Busck*), U.S. Nat. Mus. The Colombian specimens are certainly paratypes and one of them may be the type. The Panama specimen is a paratype of *E. animosella*, Dyar, which is a synonym. According to Dyar (1929, p. 16), *E. declivella* was bred from *Saissetia* sp. on *Hibiscus*; the larvae were probably only scavenging, since the scales were already attacked by a species of *Vittula*.

E. rubrimediella, Hmpsn.

rubrimediella. 1896: Hampson, 66 (*Ephestia*). 1901: Ragonot and Hampson, 278, pl. 49, fig. 10.

Forewings: sorghum brown, irrorated with white; very elongate, costa nearly straight, slightly curved towards the apex; 1st line before the middle, rather broad, only its inner margin well defined, curved, almost angulated, with its convexity outwards, inwardly margined with paler; 2nd not very strong, bisinuate near the costa, bending first inwards, then (*i.e.* nearer the costa) towards the apex, outwardly margined with paler; 3rd faint; cilia yellowish-white, orbicular and claviform distinct. Hindwings: greyish-white, narrowly margined with darker, with a faint, dark, subbasal line in the cilia. M_{2+3} and Cu_{1a} approximated at base, enclosing a long fork. Exp. ♂ 25–26·5, av. 25·7, ♀ 24–28, av. 25·9 mm.

♂. Forewing: dorsum above with no tuft of scales near base; costa not deflected, no scale-tufts. Hindwing: like that of the ♀, neither pecten dense nor yellowish.

♂. Antennae: 1st joint thickened and excised at the apex above.

♂. 8th tergite apparently not modified.

Genitalia: ♂. (Pl. VII, fig. 28.) Membranous area of the saccus covering about three-quarters of its width; costa of valve (Pl. VIII, fig. 48) produced into a tapering subapical tooth; ventral thickenings of the anellus small, the anellus anteriorly to them produced within the saccus into a plate which is approximately square, sinuate on its anterior margin; dorsal thickenings of anellus absent, replaced by broad ventral thickenings of the tegumen itself; gnathos in the shape of an elongate isosceles triangle, its apex directed posteriorly, supported on transversely placed struts; subscaphium rather strongly chitinised, especially at the sides, 5½ times as long as broad, not transversely striate; uncus longer than usual, rounded posteriorly; tegumen laterally hardly produced, lobes rounded, very short; aedeagus (Pl. VIII, fig. 49) a very elongate, subcylindrical tube, about 16 times as long as broad, with a small subapical tooth; vesica with two small chitinised areas, one bearing two, the other three, teeth.

♀. (Pl. X, fig. 87.) Ovipositor subelongate, bluntly pointed, its struts 4 times as long as the width of the 8th tergite, which is evenly chitinised, except for a triangular posterior area covering half the length of the tergite; ductus bursae evenly and rather strongly chitinised throughout, densely placed minute chitinised spots only separately visible in the immediate neighbourhood of the bursa; bursa (Pl. X, fig. 88) with no small chitinised spots, lamina dentata absent; 8th sternite with the central membranous area larger than usual, the ostium situated in its anterior margin, well in front of the posterior margin of the 7th sternite.

Specimens seen: India: 1 ♂, 1 ♀, Khasia, ♂ Mar. '94, ♀ Sept. '95; 1 ♂, 2 ♀♀, Sikkim, Sept. '09 (*F. Möller*); 1 ♀, Sikkim, 9000 ft., Sept. '95 (*J. G. Pilcher*).

The specimens from Khasia are probably paratypes; the type is in the Elwes Collection.

E. abstersella, Z.

abstersella. 1847: Zeller, *b*, 763 (*Ephestia*). 1848: Zeller, *a*, 594. 1849: Herrich-Schäffer, 110. 1896: Abafi-Aigner, 58. 1901: Ragonot and Hampson, 279, pl. 35, fig. 4; Staudinger and Rebel, 15. 1910: Spuler, 201.

Forewings: light drab, elongate, costa rather strongly curved towards apex; 1st line darker, rectangularly bent at a point nearer to the dorsum than to the costa; 2nd irregularly sinuate, strongly bent outwards towards the costa, whitish, faintly margined inwardly with darker, especially towards the costa; 3rd represented by a series of dark dots; stigmata distinct. Hindwings: whitish, narrowly margined with darker, cilia concolorous, with a distinct dark subbasal line. M_{2+3} and Cu_{1a} approximated at base, enclosing a long fork. Exp. ♂ 21 mm.

♂. Forewing: dorsum above with no tuft of modified scales near base; costa not deflected, no scale tufts. Hindwing: Like that of the female, neither pecten dense and yellowish.

♂. 8th tergite largely membranous, with a narrow central strip, ending anteriorly in a transverse bar, more chitinised; on each side of the tergite anteriorly arise three equally long tufts of modified scales.

Genitalia: ♂. (Pl. VI, fig. 26.) Membranous area of saccus covering nearly half its width; costa of valve with a broad subapical tooth; ventral thickenings of the anellus produced into a pointed dorsal and a rounded ventral lobe; dorsal thickenings of the anellus produced posteriorly into subrectangular lobes, anteriorly fused across the median line; gnathos about as long as broad, truncate posteriorly, with long lateral arms; subscaphium broader than long, transversely striate across a narrow anterior strip; uncus rounded, slightly emarginate at the apex; tegumen produced laterally into short, curved, hook-like lobes; aedeagus a simple subcylindrical tube, somewhat expanded at the apex; chitinised area of the vesica indefinite and not so long as the width of the aedeagus.

Specimen seen: SICILY: 1 ♂, Catania, 6 June, Zeller Coll. We have seen no specimen besides the type, but it has been recorded from Dalmatia by Abafi-Aigner. Zeller's specimen was captured on the leaves of *Quercus pubescens*.

E. kühniella, Z.

kühniella. 1879: Zeller, 466 (*Ephestia*). 1887: Barrett; Klein, *a*. 1889: Fletcher, *a* and *b*; Ormerod, 56 and 66, fig. 1892: Ragonot. 1893: Danysz, *c*; Decaux, C., 220, fig. 1895: Johnson, *b*. 1896: Druce, 286; Fuller. 1899: Lounsbury. 1901: Ragonot and Hampson, 279; Staudinger and Rebel, 15. 1902: Dyar, 435. 1903: Carpenter, 209. 1905: Barrett, 54, pl. 430, figs. 5, 5 *a*. 1906: Schoyen, 141, fig. 1910: Spuler, 201, pl. 82, fig. 7. 1913: Durrant and Beveridge, figs. 1914: Vorbrodt and Müller-Rutz, 309. 1918: Frickhinger, *c*. 1919: Burkhardt, figs. 1926: Curran, 385, fig. 1. 1927: Zacher, *b*, 234, figs. 1928: Candura; Hudson, 156, pl. 44, fig. 13; Meyrick, 389. 1929: Kühn and Henke, figs. 1930: Brindley; Klemm; Lebedev; Richards and Herford, 380, pl. 30, fig. 39 and pl. 31, fig. 43.
sericarium. 1859: Scott, 207, fig. (*Hyphantidium*)?. 1883: Meyrick, 160 (*Ephestia*). 1892: Ragonot (*Ephestia*).
fuscofasciella. 1887: Ragonot, *b*, 17 (*Ephestia*). 1890: Hulst, 198. 1901: Ragonot and Hampson, 278, pl. 34, fig. 13. 1902: Dyar, 434.
gitonella. 1896: Druce, 286 (*Ephestia*).
ceratoniae. 1887: Thompson (*Myelois*) *nec* Zeller.
Misspellings: *E. kuehniella* (many authors); *E. kuhniella*, Adkin (1892); *E. küehniella*, Froggatt (1912); *E. kühmiella*, Poulton (1888); *E. huchinella*, Craveri (1915); *E. kuchinella*, Bolle (1921); *E. kuehniela*, d'Utra (1901); *Epheitia kurhuirela*, Johnson (1895*a*); *Ephectia lunella*, Noel (1904).
Common names. The flour moth; The Mediterranean Flour Moth; Le papillon gris de la farine; Farfalla grigia della farina; Die Mehlmotte; Die amerikanische Mehlmotte; Kvarnmottet; Melmøl or Kvaernmøl.

Forewings: light-drab to drab-grey or mouse-grey; very elongate, costa gently curved throughout, more so towards the apex; 1st line well before the middle, indicated by a vague, darker suffusion of which the inner edge alone is sharp, and strongly sinuate near the dorsum, a very distinct pale border on its inner side, sometimes filling up most of the space between the line and the base of the wing; 2nd near the termen, rather irregular, strongly indented near the costa, outwardly margined with paler; 3rd faint; orbicular and claviform usually distinct. Hindwings; whitish grey, veins sometimes darker, margin narrowly grey, cilia white. M_{2+3} and Cu_{1a} approximated at base, enclosing a long fork. Exp. ♂ 20·5–27·5, av. 23·5, ♀ 17·5–24, av. 21·5 mm.

♂. Forewing: dorsum above with no tuft of scales near base; costa not deflected, no scale-tufts. Hindwing: like that of the female, neither pecten dense nor yellowish.

♂. 8th tergite (Pl. VIII, fig. 38) largely membranous with a fairly broad apical area, which is produced backwards as a narrow central strip, more chitinised; the central strip produced into two long arms anteriorly; at each side of the anterior end of the tergite, two broad fans of modified scales arise from small chitinised areas.

Genitalia: ♂. (Pl. VII, fig. 27.) Membranous area of saccus covering about one-third its width; costa of valve (Pl. VIII, fig. 46) produced into a curved, acuminate, apical tooth; ventral thickenings of the anellus somewhat emarginate posteriorly; dorsal thickenings reduced, consisting of elongate, not very conspicuous, chitinised bars; gnathos pentagonal, longer than broad, with no lateral arms; subscaphium rather strongly chitinised, transversely striate anteriorly, about 4 times as long as broad; uncus longer than usual, rounded posteriorly; tegumen laterally hardly produced, lobes rounded, very short; aedeagus (Pl. VIII, fig. 47) a subcylindrical tube, dilated at its apex; vesica with a narrow, bar-like, chitinised area.

♀. (Pl. X, fig. 93.) Ovipositor elongate, its struts about 4 times as long as the width of the 8th tergite, which is evenly chitinised, with a narrow, V-shaped emargination anteriorly; ductus bursae with a number of small, chitinised spots in the region of the bursa; bursa (Pl. X, figs. 91 and 92) with no small chitinised spots, the lamina dentata replaced by 1–4 (usually 2) chitinised plates, in which a small, subcircular area is more hyaline.

E. kühniella, Zell., is one of the most easily recognisable species, though we found one specimen from the Zeller Collection in the series of *E. figulilella*, Gregs., and one specimen of *E. calidella*, Gn., in the series of *E. kühniella*, Zell. *E. gitonella*, Druce, from various localities in Mexico is identical with *E. kühniella*, Zell. Specimens in the British Museum Collection identified as *E. fuscofasciella*, Rag., are structurally identical with *E. kühniella*, Zell., but are rather darker in colour, the 1st line being particularly broad. Moreover, Whiting's genetic studies (1919) show that there are several different hereditary dark colour varieties in *E. kühniella*, Zell. In our account of the specimens seen, these three names are treated as synonymous.

Specimens seen: British Isles: London, numerous specimens in the Banks Coll. and the British Museum Coll.; Sonning, Berks., Oct. '29, flour mill (*N. S. Noble*); Italy: 1 ♂, 1 ♀, Quiesa, June, coll. Turati; Canaries: 1 ♂, 1 ♀, Guimar, Teneriffe, 10 April '07 (*Walsingham*); East Africa: 1 ♂, 1 ♀, Lumbwa, Kenya, 24 Aug. '23 (*G. W. Jeffery*); U.S.A.: 1 ♀, Algonquin, N. Illinois, 21 May; Mexico: 3 ♂♂, Panajachel, 5000 ft., Godman-Salvin Coll.; 1 ♂, 1 ♀, Cuidad, 8100 ft. (*Farrer*), Godman-Salvin Coll.; 1 ♂, Jalapa (*M. Trujillo*), Godman-Salvin Coll.

If we add to the records given above the distribution recorded in the literature, we find that the present-day distribution of *E. kühniella* is almost world-wide though with certain notable exceptions. It is not found in the Far East, nor in Africa south of the Atlas Mts., except as a local introduction in Cape Town and E. Africa. The following are some of the more important records:—Norway (Schøyen, 1906); Sweden (Tullgren, 1905); Germany (described by

Zeller, 1879; numerous localities, Karsch, 1885; Johnson, 1895*b*, states that a German miller, then resident in California, recalled seeing the moth in Schleswig in 1858); Belgium (de Borre, 1884); Holland (Snellen, 1881); Russia (Ekaterinoslav, Vitkovsky, 1915; Don Province, Zvierezomb-Zubkovsky, 1918, etc.); Bulgaria (Tchorbadjef, 1929); Hungary (Abafi-Aigner, 1896); Switzerland (Vorbrodt and Müller-Rutz, 1914); Italy (Candura, 1928); S. France (Cavanna, 1884); Algeria (Holl, 1911); Cyrenaica (Turati, 1924); Turkey (Constantinople, Danysz, 1893*b*); S. Africa (Lounsbury, 1899); Canada (Fletcher, 1889*b*); U.S.A. (N. Carolina, Girard, 1884; Riley, 1889, however, states that it was not then known in the U.S.A.); Jamaica (Gowdey, 1922); British Guiana (Bodkin, 1923); Chile (Girard, 1884); Australia (Fuller, 1896; Scott's record, 1859, of *Hyphantidium sericarium* probably refers to the present species); Tasmania (Nicholls, 1921); New Zealand (Miller, 1922).

In Great Britain, the first record was from Stoney Stratford, Bucks (Barrett, 1887): it occurred in London at about the same time (Klein, 1887*a* and *b*); later it was known in the Isle of Man (Crennell, 1898) and Ireland (Carpenter, 1903); according to Barrett (1905) it is found in Britain as far north as Aberdeen.

The country of origin of this pest is very uncertain and various suggestions have been put forward. The actual facts are few and partly not well established. There is no absolutely certain record of the moth prior to Zeller's description in 1879. Yet in a few years it had become a pest throughout the greater part of Europe and within twenty years it was giving trouble in many districts of N. America.

The problem is difficult and can only be solved by the consideration of indirect evidence. At the time that it was first described in Germany it is almost certain that it had been already spread considerably by commerce, while Scott's doubtful record from Australia (1859), Johnson's information (1895*b*) that it was known in Germany in 1858 and the evidence adduced by Durrant and Beveridge (1918, pp. 10–13) to show that *E. kühniella* may have existed in British army biscuits in 1801 and that it was breeding in native-grown flour in Mexico and Guatemala in 1880–1, still further complicate the problem. Durrant and Beveridge, in fact, maintain (p. 13) that *E. kühniella* is a native of Central America which has been carried from there in flour.

If we examine the genus *Ephestia* as a whole we find the species have the following distribution. Mediterranean Basin (in the broadest sense), 37 species; Madagascar, 1; India, 2; Christmas Island, 1; N. America, 2; Central and South America, perhaps 11, but most, if not all, of these are not typical Ephestias. *E. kühniella* has no close ally, but it is at least more probable that it should be a native of the Mediterranean Basin than of America. More than that it is impossible to say.

Lebedev (1930) and Klemm (1930) have advanced the theory that *E. kühniella* first became a pest in the regions of Asia Minor where the cultivation of wheat was begun by the Sumerians; this is quite possible but sufficient positive evidence is lacking.

Fölsch (1926) thinks that *E. kühniella* was originally a beehive pest which turned its attention to flour when the steam-mills provided it with ideal conditions. It seems much more probable to us that the records of the occurrence of *E. kühniella* in beehives are based on misidentifications of the larvae of *Galleria mellonella*, L., and *Meliphora grisella*, F. This is also the opinion of Hering (1926) and Lebedev (1930). On the other hand there is little doubt that it was owing to the widespread adoption of steam-mills towards the end of the last century that *E. kühniella* became a pest so suddenly; when it had once become abundant in one mill it was only a matter of time for its range to become world-wide. Several other insects, e.g. *Ptinus tectus*, Boield., or *Niptus hololeucus*, Fald., have had a similar though less spectacular spread in recent years.

E. kühniella is pre-eminently a pest of flour, especially in steam-mills where a high temperature is maintained throughout the year, see Danysz (1893*b*), Fletcher (1890*a* and *b*), Carpenter (1903), etc. No stage is ever found out of doors. The following foods have been recorded:—Wheat flour (most authors); rice flour, Girault (1912); buckwheat flour, Johnson (1895*b*); barley, Candura (1928); rye, Candura (1928); rye meal, Pagenstecher (1885), Landois (1886), Fuchs (1897); bran, Riley (1894), Candura (1928); biscuits, Johnson (1895*b*), Girault (1912), Durrant and Beveridge (1913), Durrant (1921), Dieuzeide (1926); cakes, Riley (1894); maize, Barrett (1905); maize-meal, Landois (1886); oatmeal, Johnson (1895*b*), Girault (1912); rice, Fuchs (1897), Andres (1918), Jack (1923); rice-cones, Barrett (1887); ground rice, Adkin (1887); macaroni, Snellen (1881), Durrant (1921); Allison's baby food, Tutt (1895); soy beans, Candura (1928); potatoes, Dieuzeide (1926); cacao, Knapp (1923), Dieuzeide (1926), Zacher (1926); chocolate, Candura (1928); cotton seed, Newell and Smith (1905), Girault (1912); hemp seed, Candura (1928); sesame seed, Candura (1928); linseed meal, Landois (1886); dried mushrooms, Pagenstecher (1885); walnuts, Müller-Rutz (1927); almonds, Candura (1928); peas, Lyne (1918); beans, Lyne (1918), Sheppard (1926), Candura (1928); peanuts, Lyne (1918); acorns, Seidel (1930); chillies, Sheppard (1926); chestnut flour and dried chestnuts, Candura (1928); jelly cubes, Wadsworth (1919); dead insects, Wadsworth (1919).

A certain number of authors—Smith (1910), Newman (1923), Lyon (1924)—have recorded *E. kühniella* as a pest of dried fruits. We think it likely that these records are due to misidentification. In some experiments conducted in this laboratory the larvae of *E. kühniella* failed to grow properly on such food. Another record from fruit is that of Gowdey (1927), who records it from dried bananas.

Davidson (1894), Johnson (1895*b*) and Chittenden (1900) state that the larva may live in the nests of wild bees (*Bombus*); this is also likely to be due to misidentification; a somewhat similar Phycitid, *Vittula edmandsii*, Pack., might be the source of the confusion. Gillette (1898) also records larvae which he identified as those of *E. kühniella* feeding on pollen in beehives. Johnson (1895*b*) also notes that it has been found in hives. Personally we have not yet been able to rear *E. kühniella* larvae on old bee comb.

The record of Anon. (1923) that in S. Africa the larva feeds in the heads of *Gerbera jamesoni* is perhaps due to the misidentification of some other Phycitid larva.

Landois (1886), Johnson (1895*b*) and Candura (1928) give some information with regard to food-preferences and on the effect of the different foods on the length of the life-history, while Richardson (1926) has studied the relation of the various constituents of wheat flour to the growth of the larva.

The following parasites and predators have been recorded. *Nemeritis canescens*, Grav., *Limneria ephestiae*, Ashmd., *Omorgus columbianus*, Ashmd., *Angitia incipiens*, Walley ?, *Mesostenus gracilipes*, Cress., *Microbracon hebetor*, Say, *M. brevicornis*, Wesm., *Apanteles ephestiae*, Baker ?, *Chremylus rubiginosus*, Nees, *Lariophagus distinguendus*, Först., *Trichogramma evanescens*, Westw., *Gnathocerus cornutus*, F., *Tribolium confusum*, Duv., *T. castaneum*, Herbst., *Tenebroides mauretanicus*, L., *Pediculoides ventricosus*, Newp., *Seiulus muricatus*, Koch, *Mus musculus*, L., *Thelohania ephestiae*, Mattes, *Micrococcus ephestiae*, Mattes, Schizogregarine sp., *Bacillus thuringiensis*, Berliner, *B. agilis*, Mattes.

E. tephrinella, Led.

tephrinella. 1870 : Lederer, 41 and 53, pl. 2, fig. 12 (*Myelois*). 1879 : Fuchs, 46 (*Euzophera*). 1901 : Ragonot and Hampson, 287 (*Ephestia*); Staudinger and Rebel, 15. 1910 : Spuler, 202. 1914 : Vorbrodt and Müller-Rutz, 310. 1916 : Andres, 51. 1922 : Müller-Rutz, 218. 1927 : Müller-Rutz, 501.
mediterranella. 1874 : Millière, 248 (*Zophodia*). 1875 : Millière, 264, pl. 2, fig. 14 (*Euzophera*).
rhenanella. 1877 : Fuchs, 147 (*Euzophera*).

Forewings : near tilleul-buff, irrorated with white towards the base and on the costa; very elongate, costa almost straight; 1st line before the middle, not oblique, nearly straight, slightly bent towards the base of the wing near the costa, rather broad, inwardly margined with white; 2nd near the apex, subparallel to the termen, nearly straight but slightly sinuate near the dorsum; white, inwardly margined with dark; 3rd not distinguishable; orbicular and claviform distinct. Hindwings : whitish-grey, narrowly margined with darker, cilia whitish. M_{2+3} and Cu_{1a} approximated at base, enclosing a long fork. Exp. ♀ 23 mm.

Genitalia : ♀. (Pl. X, fig. 89.) Ovipositor elongate, rounded at apex, the struts nearly 4 times as long as the width of the 8th tergite; 8th tergite nearly twice as long as broad, evenly chitinised, anteriorly broadly emarginate; ductus bursae with a fairly dense patch of small chitinised spots in the neighbourhood of the bursa; bursa with no small chitinised spots, the lamina dentata replaced by 6 chitinised plates (Pl. X, fig. 90), each of which has a narrow, reflexed edge. 7th sternite with two rectangular, more chitinised areas.

Specimens seen : France : 1 ♀, S. France (*Ragonot*), Zell. Coll. This specimen was labelled by Ragonot as *E. mediterranella*, Mill. = *E. tephrinella*, Led.

E. tephrinella was described from Transcaucasus and Magnesia, Asia Minor, where the adults were found hopping about on the leaves of *Tamarix smyrnense*. It is further recorded from Malta, Sicily, Sardinia, S. France, Switzerland and Germany.

E. welseriella, Z.

welseriella. 1848 : Zeller, *b*, 673 (*Myelois*). 1849 : Herrich-Schäffer, 106, pl. 12, fig. 83 (*Homoeosoma*). 1865 : von Heinemann, 194 (*Steganoptycha*). 1870 : Lederer, 53 (*Myelois*). 1901 : Ragonot and Hampson, 286, pl. 35, fig. 7 (*Ephestia*); Staudinger and Rebel, 15. 1910 : Spuler, 202. 1911 : Holl, 22.

Forewings : white, elongate, costa straight; 1st line brown, rather before the middle, nearly straight, with an inward projection before the costa ; 2nd very uneven, in particular with a large outward sinuation towards the tornus; 3rd distinct; stigmata strong, in some specimens connected. Hindwings : white, narrowly margined with fuscous, cilia white, with a faint, creamy subbasal line. M_{2+3} and Cu_{1a} approximated at base, enclosing a long fork. Exp. ♂ 22·5–25, ♀ 27 mm.

♂. Forewing : dorsum above with no tuft of modified scales at base; costa not deflected. Hindwing : no area of modified scales : neither pecten dense nor yellowish.

♂. 8th tergite (Pl. VIII, fig. 37) largely membranous, with a moderately broad apical area which is produced anteriorly into a narrow central strip, more chitinised ; the central strip ending anteriorly in a transverse bar; on each side of the tergite anteriorly arises a large tuft of modified scales.

Genitalia : ♂. (Pl. VII, fig. 29.) Membranous area of the saccus covering a little more than one half of its width; costa of valve without a tooth; ventral thickenings of the anellus produced on each side into a narrow anterior and a broad posterior lobe; dorsal thickenings of the anellus consisting of moderately broad, parallel-sided strips; gnathos longer than broad, with long lateral arms; subscaphium laterally serrate and transversely striate anteriorly, 2½ times longer than broad; apex of uncus rounded; tegumen laterally produced into short rounded lobes; aedeagus a simple subcylindrical tube; chitinised area of vesica rather indefinite, about half as long as the aedeagus.

♀. (Pl. XI, fig. 102.) Ovipositor rounded, its struts nearly twice as long as the width of the 8th tergite, which is moderately strongly chitinised throughout, especially over a tongue-shaped median area and a narrow anterior strip; the tergite is posteriorly broadly emarginate; ductus bursae membranous throughout; bursa (Pl. XI, fig. 103), with 43 conical chitinisations in its wall, lamina dentata absent.

Specimens seen: RUSSIA: 1 ♀, Sarepta (*Chr.*), Zeller Coll.; 2 ♂♂, Sarepta (*Chr.*), 1, March, '69, 1, '75, Zeller Coll. The ♀ specimen is marked as the type of the species. *E. welseriella* was originally described from Ragusa and Hungary. Possibly the real type is in the Berlin Museum. The species is further recorded from Spain, Dalmatia, Algeria and Asia Minor.

E. dowsoniella, sp. n.

Head, thorax and palps with whitish scales. Forewings: on the costal half white, on the dorsal half white, pale brown and dark grey, equally mixed; 1st line white, rather before middle, strongly but not angularly bent inwards on costal half, on dorsal half broadly margined inwardly with pale brown; 2nd well beyond the middle, a little oblique, brown, inwardly margined with white, a little sinuate inwards on the disc; 3rd consisting of an indistinct series of dots; orbicular distinct, claviform absent. Hindwings: pale grey, very narrowly margined with fuscous, cilia white, with a faintly darker subbasal line. M_{2+3} and Cu_{1a} approximated at base, enclosing a long fork. Exp. ♀ 17 mm.

♂. Unknown.

Chaetosema with unusually long white bristles, almost as long as the scales bordering the back of the head on the dorsal part of the occiput.

Genitalia: ♀. Ovipositor rounded, its struts two and a half times as long as the width of the 8th tergite, which is strongly chitinised throughout, posteriorly distinctly emarginate, anteriorly almost straight; the chitinised lobes of the 8th sternite (Pl. X, fig. 94) projecting strongly on the disc as two angular lobes; ductus bursae membranous throughout; bursa with 60 or more conical chitinisations in its wall, lamina dentata absent.

Type. IRAQ: Basra, 1 ♀, flying to light, 15 Oct. '30 (*V. H. Dowson*). Deposited in the British Museum collection.

E. rileyella, Rag.

rileyella. 1887: Ragonot, *b*, 17 (*Ephestia*). 1890: Hulst, 198. 1901: Ragonot and Hampson 294, pl. 34, fig. 22. 1902: Dyar, 435.

Head with a distinct cone of black scales; last segment and apex of penultimate segment of labial palpi with black scales externally. Forewings: white, elongate, costa slightly curved towards apex; base of costa black in both sexes, the black area greater in the ♂ than in the ♀; 1st line slightly before the middle, straight, represented by three black dots; 2nd nearer to the termen than to the 1st line, nearly straight, slightly oblique towards the apex, represented by a series of black dots; 3rd distinct; orbicular distinct, claviform absent. Hindwings: white, narrowly margined with brownish-grey, cilia white with a very faint darker subbasal line. M_{2+3} and Cu_{1a} shortly stalked at base, enclosing a short fork. Exp. ♂♀ 20 mm.

♂. Forewing : dorsum above with no tuft of scales at base; base of costa deflected, enclosing modified scales. When the costal fold is not expanded, the ends of a few broad, white scales protrude at the base, and some long narrow white ones at the apex. Hindwing : no area of yellowish scales in front of the cubital pecten; neither the cubital nor the anal pecten dense or yellowish.

♂. 8th tergite (Pl. VIII, fig. 42) almost entirely membranous, with a narrow central chitinised strip, which ends anteriorly in a small, triangular expansion; on each side of the tergite anteriorly arise three to four tufts of modified scales; of these tufts one is longer and broader than the others, curved apically towards the median line.

Genitalia : ♂. (Pl. VII, fig. 33.) The membranous area of the saccus covering more than half its width; costa of valve not produced into a tooth; ventral thickenings of the anellus small, bilobed, dorsal thickenings elongate, posteriorly fused across the median line, with a blunt tooth on their inner margins shortly before the point of fusion; gnathos approximately pentagonal, posteriorly truncate, with no lateral arms; subscaphium not transversely striate; uncus broadly rounded; tegumen laterally produced into short, rounded lobes; aedeagus a simple subcylindrical tube, chitinised area of vesica of moderate size.

♀. (Pl. X, fig. 86.) Ovipositor bluntly rounded; 8th sternite a little longer than broad, evenly chitinised except for a broadly triangular, posterior membranous area which stretches back in the centre to about one-third the length of the tergite; struts both of the ovipositor and of the 8th tergite a little more than 1½ times the width of the tergite; ductus bursae posteriorly evenly chitinised, slightly expanded towards the apex and thrown into several folds at this point, a bluntly rounded process arising at the extreme apex; bursa (Pl. X, fig. 85) with a group of small chitinised spots in its wall, the lamina dentata replaced by a single chitinised plate.

Specimens seen : U.S.A. : 1 ♂, 1 ♀, Chiricahua Mts., Arizona, from *Yucca* seed-pods (*C. Heinrich*), U.S. Nat. Mus.

E. rileyella was recorded as bred from the fruit of *Yucca baccata* in the original description. It is found in Utah, New Mexico, Arizona and Mexico.

E. micaceella, Rag.

micaceella. 1901 : Ragonot and Hampson, 298, pl. 49, fig. 17 (*Ephestia*).

Described from one male bred from a caterpillar living in the cocoon of *Attacus orizaba* from Mexico.

The following male in the collection of the British Museum was identified by Hampson as *E. micaceella*, Rag. It does not altogether agree with the original description and figure, but is at any rate a species distinct from any that we have examined.

Forewings : light drab; elongate, costa nearly straight; 1st line at about the middle, nearly straight, rather sharply defined, narrowly margined with paler on its inner side; 2nd rather nearer to the termen than to the 1st line, nearly straight, oblique towards the apex, outwardly margined with paler; 3rd hardly indicated; termen narrowly margined with fuscous; orbicular strong, claviform absent. Hindwings : whitish grey, veins darker, margin narrowly grey, cilia whitish. M_{2+3} and Cu_{1a} shortly stalked at base, enclosing a short fork. Exp. ♂ 21 mm.

♂. Forewing (Pl. V, fig. 9) : dorsum above with no tuft of scales at base ; base of costa deflected, enclosing broad white scales at the base, followed by a dense tuft of long, spatulate, white ones, and at the apex a tuft of long, grey hair-scales. When the costal fold is not expanded, the ends of a few broad, white scales protrude at the base and some long narrow white ones at the apex, its appearance not being very different from that of

E. elutella, Hb. Hindwing: no area of yellow scales in front of the cubital pecten; neither the cubital nor the anal pecten dense and yellowish.

♂. 8th tergite and its modified scales were not in a condition to describe in the single specimen we were able to examine.

Genitalia: ♂. Membranous area of saccus covering about a quarter of its width; costa of valve not produced into a tooth; ventral thickenings of the anellus small, bilobed, dorsal thickenings absent, replaced by broad ventral thickenings of the tegumen itself; gnathos large, pentagonal, posteriorly truncate, with no lateral arms; subscaphium not transversely striate; uncus broadly rounded; tegumen laterally produced into short, rounded lobes; aedeagus a simple, subcylindrical tube; chitinised area of vesica of moderate size.

We have been able to examine only one ♂ of this species. MEXICO: Oaxaca.

E. mistralella, Mill.

mistralella. 1874: Millière, 250 (*Euzophera*). 1886: Millière, 46 (*Euzophera*). 1901: Ragonot and Hampson, 295 (*Ephestia*); Staudinger and Rebel, 16 (*Ephestia*).
E. mistralella, Mill. var. *metoenella*, Zerny. 1927: Zerny, 133, pl. 2, fig. 14–5.

Described from the S. of France, the variety from Spain.

The following specimen was identified, presumably by Hampson, as *E. mistralella*, Mill. This is possibly correct, but the specimen is scarcely distinguishable from *E. moebiusi*, Reb. If the specimen really is *E. mistralella*, then *E. moebiusi* will have to be sunk as a synonym.

Forewings: drab-grey irrorated with white; elongate, costa nearly straight, slightly more curved towards the apex; 1st line faint, well before the middle of the wing, running obliquely outwards from the dorsum, but nearer the costa bending sharply inwards, not margined with paler on its inner side; 2nd faint, straight, and oblique towards the apex, outwardly faintly margined with paler; 3rd faint; orbicular faint, claviform absent. Hindwings: grey, margin narrowly darker, cilia whitish, with a faint subbasal dark line; M_{2+3} and Cu_{1a} shortly stalked, enclosing a short fork. Exp. ♂ 16 mm.

♂. Forewing: dorsum above with no tuft of scales at base; base of costa not deflected, scales on the underside of the base of costa merely somewhat elongate. Hindwing: cubital pecten preceded by an area of yellowish scales which tend to lie along the veins, including the cubital vein itself; neither the cubital nor the anal pecten dense or yellowish; the anal pecten preceded by a minute tuft of broad, yellowish scales.

♂. 8th tergite and its modified scales were not in a condition to describe in the single specimen we were able to examine.

Genitalia: ♂. (Pl. VI, fig. 18.) Very similar to *E. elutella*, Hb.; costa of valve without a tooth; dorsal thickenings of the anellus posteriorly produced inwardly into a small lobe at the point where they curve outwards, the curve itself less acute than in *E. elutella*, Hb.; gnathos broader than long, anteriorly with a slight emargination, posteriorly with rather long lateral arms; aedeagus thicker (Pl. VIII, fig. 56) compared with its length than that of *E. elutella*, Hb.

We have been able to examine only one ♂ of this species. SPAIN: Branuelas, 10–16 July '07 (*T. A. Chapman*).

E. moebiusi, Reb.

moebiusi. 1906: Rebel, 229 (*Ephestia*).

Practically identical with *E. mistralella*, Mill. Forewings: 1st line sometimes rather indefinitely margined inwardly with white. Exp. ♂ 17–19·5, av. 18·3 mm.

♂. 8th tergite (Pl. VIII, fig. 41) almost entirely membranous, with a rather narrow central chitinised strip which is broader and trifurcate posteriorly, and anteriorly ends in a subtriangular expansion; on each side of the tergite anteriorly arise three, not clearly separated, tufts of spatulate scales.

Genitalia : ♂. (Pl. VI, fig. 16.) As in *E. mistralella*, Mill., but the inner posterior lobes of the dorsal thickenings of the anellus are more produced inwards, just fusing on the median line, the outwardly curved lobes narrower, sometimes a little expanded at the apex.

We have seen 8 ♂♂ of this species bought from Staudinger (Lössnitz, Dresden, E. Möbius, 2 ♂♂, 16 July '12, 4 ♂♂, 24 July '13, 2 ♂♂, 5 July '20).

The differences between this form and the single specimen we describe as *E. mistralella*, Mill., are very slight, and are probably due only to individual variation. Further material is necessary to settle this point.

1 ♀ (Lauban, Feb. '77, Zell. Coll.) was placed under *E. moebiusi*, Rebel, in the British Museum Collection. It agrees fairly closely with the ♂♂ of *E. moebiusi*, Rebel, in the wing-markings; the genitalia resemble those of *E. elutella*, Hb., but the central process of the posterior chitinised area of the 8th sternite is broader and more rounded, though not quite so much so as in *E. woodiella*, sp. n.; the small chitinised spots in the ductus bursae are barely visible, and the lamina dentata is replaced by 18 chitinised plates (Pl. X, fig. 83), many of them being of half the usual size.

E. elutella, Hb.

elutella. 1796* : Hübner, pl. 24, fig. 103 (*Tinea*). 1818 : Zincken, 175 (*Phycis*). 1832 : Treitschke, 194 (*Phycis*). 1834 : Stephens, 304 (*Phycita*). 1836 : Duponchel, 204, pl. 279, fig. 8 (*Phycis*). 1837 : Wood, W., 210, pl. 46, fig. 1454 (*Phycita*); Zeller, *a*, 176; *b*, 343 (*Myelois*). 1845. Guenée, *a*, 81; *b*, 319 (*Ephestia*) : Westwood and Humphreys, 229, pl. 115, fig. 7 (*Phycita*). From this date onwards authors use the generic name *Ephestia*. 1849 : Herrich-Schäffer, 110. 1859 : Stainton, 168. 1865 : von Heinemann, 201. 1871 : Wallengren, 1053. 1872 : Morris, 1114, pl. 79, fig. 18. 1875 : Barrett, 269. 1880 : Frey, 279. 1882 : Snellen, 162. 1886 *n* : Leech, 94, pl. 11, fig. 3. 1901 : Ragonot and Hampson, 300; Staudinger and Rebel, 16. 1902 : Dyar, 435. 1905 : Barrett, 58, pl. 431, figs. 1, 1*a*, 1*b*, 1*c*, 1*d*. 1907 : Reh. 1910 : Spuler, 202, fig. 69 and pl. 82, fig. 8. 1913 : Durrant and Beveridge, 615. 1914 : Vorbrodt and Müller-Rutz, 310. 1925 : van Emden, *a*, 192–220, pl. 8, figs. 13 and 14; *b*, 91. 1926 : Curran, 386, fig. 2; Zacher. 1927 : Zacher, *b*, 242, figs. 1928 : Meyrick, 388. 1929 : Munro and Thomson, 22, pl. 1, pl. 3, fig. 1, pl. 4, fig. 1. 1930 : Richards and Herford, 380, pl. 28, pl. 30, fig. 38 and pl. 31, fig. 44.

elutella. 1898 : Froggatt, 1103, fig. (*Ephestia*). 1903 : Froggatt, 490 (*Ephestia*) *nec* Hübner see *Plodia interpunctella*, Hb.

elutella. 1915 : Mason (*Ephestia*) *nec* Hübner see *E. cautella*, Wlk.

elutea. 1811 : Haworth, 497 (*Phycis*).

gemina. 1811 : Haworth, 497 (*Phycis*) ?

rufa. 1811 : Haworth, 497 (*Phycis*).

semirufa. 1811 : Haworth, 496 (*Phycis*). 1834 : Stephens, 305 (*Phycita*). 1837 : Wood, 210, pl. 46, fig. 1457 (*Phycita*). 1845 : Westwood and Humphreys, 229, pl. 115, fig. 10 (*Phycita*). 1879 : Staudinger, 229 (*Ephestia*) ? 1880 : Curo, 91 (*Ephestia*) ? 1886 : Leech, 96 (*Ephestia*) in part. For the remaining synonymy of the name *semirufa* see under *E. woodiella*, sp. n.

unicolorella. 1879 : Staudinger, 228 (*Ephestia elutella* var.). 1881 : Staudinger, 89 (*Ephestia*). 1901 : Ragonot and Hampson, 299, pl. 35, fig. 11; Staudinger and Rebel, 16. 1910 : Spuler, 202.

roxburghii. 1873 : Gregson (*Ephestia*). 1885 : Ragonot, 25. 1891 : Barrett. 1901 : Ragonot and Hampson, 301, pl. 35, fig. 14. Hulst (1890, p. 200) incorrectly refers *E. roxburghii* to *Plodia interpunctella*, Hb., but Ragonot and Barrett both saw some of the original specimens.

roxburgii. 1901 : Staudinger and Rebel, 16 (*Ephestia*).

roxburghi. 1910 : Spuler, 202.

amarella. 1904 : Dyar, *b*, 921 (*Ephestia*).

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* We accept the date given by Sherborn in his Index Animalium (pt. I, p. 326).

parasitella. 1884 : Kirby (*Ephestia*) *nec* Staudinger.
granella. 1900 : Stitz, 151–4, pl. 7, fig. 14, pl. 8, figs. 7–9, pl. 9, figs. 1, 16 and 22 (*Tinea*) *nec* Linné.

Common names : Possibly " Petite chenille . . . trouvé dans un morçeau de pain sec " of De Geer (1752, p. 516) is this species ; see Zeller (1839*b*, 516). Red-streaked Knothorn ; Chocolate moth ; Currant moth ; Walnut moth ; Graue Dörrobstmotte ; Heumotte.

Forewings (Pl. V, fig. 5) : light-drab, sometimes darker (drab), or with less yellow (pale drab-grey, drab-grey, smoke-grey, light to deep mouse-grey), or browner (hair-brown, wood-brown, buffy-brown), or yellowish (avellaneous, pinkish buff) ; elongate, costa gently curved throughout ; 1st line rather before the middle, straight, oblique towards the base of the costa, varying from little to distinctly darker than the ground-colour, usually margined inwardly with paler ; 2nd well beyond the middle, usually fairly distinct and bordered inwardly with paler, this again often margined inwardly with darker ; 3rd usually distinct ; orbicular present in about half the specimens, claviform nearly always absent. Hindwings : whitish or greyish, narrowly margined with grey, cilia usually without a dark subbasal line. M_{2+3} and Cu_{1a} shortly stalked, enclosing a short fork. Exp. ♂ 13·5–19·5, av. 15·6, ♀ 14–19·5, av. 15·9 mm.

♂. Forewing (Pl. V, fig. 8) : dorsum above near the base with a small tuft of yellowish modified scales, base of costa deflected, enclosing short, clubbed, orange hair-scales and, at the apex, some long white hair-scales. When the costal fold is not expanded only ordinary scales are seen on it, except for the tips of a few long hair-scales protruding from its apex. Hindwing (Pl. V, fig. 6) : a large area of yellow scales in front of the cubital pecten, which is dense and yellowish like the anal pecten ; anal pecten preceded by a small tuft of broad, yellowish scales.

♂. 8th tergite (Pl. VIII, fig. 40) almost entirely membranous, with a narrow central chitinised strip, which ends anteriorly in a small, triangular expansion ; on each side of the tergite anteriorly arise four tufts of modified scales ; of these tufts the outer one is the longest and broadest, the innermost one rather shorter and narrower ; one of the intermediate ones is as long as the innermost one, but not half its width, while the fourth tuft is very short, not one-quarter as long as the others.

Genitalia : ♂. (Pl. VI, fig. 15.)* The membranous area of the saccus covering about three-quarters of its width ; costa of valve (Pl. VIII, fig. 54) simple, with no tooth ; ventral thickenings of the anellus about as long as broad ; dorsal thickenings elongate, posteriorly curved outwards into a broad hook ; gnathos triangular, with short lateral arms ; subscaphium weakly chitinised, anteriorly faintly striate ; apex of uncus rounded ; tegumen laterally produced into short, broad lobes ; aedeagus (Pl. VIII, fig. 55) a simple, subcylindrical tube ; chitinised area of the vesica large, half as long as the aedeagus.

♀. (Pl. X, fig. 81.) Ovipositor elongate, rounded at apex ; 8th tergite quadrate, with two large, antero-lateral membranous areas, leaving a rather narrow posterior chitinised strip, which is produced on the median line into a long, acuminate, tooth-like process ; ductus bursae with numerous small chitinised spots in the region of the bursa ; bursa (Pl. X, fig. 80) with no small chitinised spots, the lamina dentata replaced by 7–10 chitinised plates.

Specimens seen : *E. elutella*, Hb., appears, from the collections we studied, to be confused occasionally with *E. cautella*, Wlk., *figulilella*, Gregs., and *woodiella*, sp. n., while *E. parasitella*, Stgr., was found misidentified as *E. elutella*, Hb. The following records are based on specimens whose genitalia we have examined :—British Isles : 1 ♂, Corfe, 27 July '88, Banks Coll. ;

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* Stitz (1900) figured the genitalia of this species under the name of " *Tinea granella.*"

1 ♂, 1 ♀, Lewisham, Stainton Coll., ♂ 22 May, ♀ 29 June, '48; 1 ♀, Dartford Heath, 19 April '48, Stainton Coll.; 1 ♀, Britain, Stephens Coll.; 2 ♀♀, Britain, Sheppard Coll.; 1 ♂, Brandon, 9 July '88; 3 ♀♀, 1 ♂, Bournville, '22 (*R. V. Wadsworth*); 1 ♂ in the British Museum (Nat. Hist.), 7 Aug. '94; numerous specimens from docks and warehouses in London, see Richards and Herford (1930); LATVIA: 1 ♂, Livonia, Zell. Coll.; CENTRAL EUROPE: 1 ♂, 2 ♀♀, bred *Ceratonia*, 11 Aug., 28 May and 3 Aug. '82, respectively; 1 ♂, Raibl, 12 July '67, Zell. Coll.; 1 ♂, Aube, 12 Aug. '82, Zell. Coll.; 1 ♀, Brück a/Z., July '59, Zell. Coll.; ITALY: 1 ♂, Fiume, 3 Sept. '49, Zell. Coll.; 1 ♂, 1 ♀, Syracuse, 5 and 6 May '44, Zell. Coll.; and the following specimens from coll. Turati–Reggio Emilia, 2 ♀♀ no date, 1 ♀ 31 May '21, 1 ♀ 24 Sept. '22, 1 ♀ 8 Aug. 23, 1 ♀ 7 Aug. 24, 1 ♀ 22 Aug. '26, 4 ♀♀ July '29; 1 ♂, Ficuzza, Sicily, 30 Aug.; Tessin, Maroggia, 1 ♀ 1 July, 1 ♀ 15 June; 1 ♀, Appenn. Moden., Sestola, 11 July, '19; Valsassina, Primalura, 1 ♀ 6 Aug. '12, 1 ♂, 1 ♀ 12 July '14, 2 ♀♀ 20 July '14, 1 ♀ 14 Aug. '14; 1 ♂, no locality, 21 Aug.; RHODES: 1 ♀ (*Löw*), Zell. Coll.; PALESTINE: 1 ♂ '84; ALGERIA: 1 ♀, Hamman-es-Salahain, 12 April '04 (*Walsingham*); 1 ♀, Tangiers, Stainton Coll.; CANARIES: 1 ♀, Guimar, Teneriffe, 17 Mar. '07 (*Walsingham*); INDIA: 1 ♀, Bay of Bengal, at sea, 21 Jan. '08 (*Meade-Waldo*); AUSTRALIA: 1 ♂, near Melbourne, 1 Mar. '90 (*Anderson*); 1 ♀, S.E. Australia, Raynor Coll.; BRAZIL: 1 ♂, Para, 4 Jan. '96 (*E. E. Austen*).

A series of moths in the British Museum Collection identified as *E. amarella*, Dyar, proved to be identical with *E. elutella*, Hb. They were from the following localities:—BRITISH COLUMBIA: 1 ♂, 1 ♀, New Westminster, 13 June and 11 July '00 (*C. Durrant*); 1 ♂, 1 ♀, Kasle, 7 June '04 (*J. W. Cockle*).

A specimen in the British Museum Collection identified as *E. bizonella*, Rag. (1 ♀, Teneriffe, *W. White*), is also indistinguishable from *E. elutella*, Hb.

A specimen in the British Museum Collection identified as *E. zosteriella*, Rag. (1 ♀, Syria, Leech Coll.), is structurally identical with *E. elutella*, Hb., but is very different in colour. The forewings are between vinaceous-buff and tilleul-buff, costa white irrorated, all the lines marked, but the 1st rather faint, the claviform distinct. Hindwings white, not margined with grey, cilia concolorous. There are 9 chitinised plates in the bursa.

The type of *E.* (*Phycis*) *semirufa*, Haworth, is apparently lost, but there is no reason to doubt that it was a form of *E. elutella* in which the reddish dorsal streak was unusually developed. A number of the references in literature to *E. semirufa* refer to the same form. Stainton, however, in 1859 used the name for a distinct species, which we describe as *E. woodiella*, sp. n. (p. 191).

E. roxburghii, Gregson, appears to be a variety of *E. elutella* in which the markings are very clear, the basal third of the forewings is rather pale and the remainder rather dark. We have seen no specimens corresponding exactly to Gregson's description, but somewhat similar varieties have been shown by Whiting in the case of *E. kühniella* to be due to a single mutation. It is quite likely that this was also the case with *E. roxburghii*, which is not known apart from the original specimens.

We have bred another remarkable form from some larvae found in prunes imported from Cyprus. In this variety the wings are very dark fuscous, almost black, and the two lines are whitish, showing up strongly by contrast, and nearly straight.

E. unicolorella, Staudinger, is a dubious form, certainly very closely allied to *E. elutella*. The type male, from Staudinger's description, might, perhaps, be a variety of *E. parasitella*, Stdgr., in which the markings were rather obsolete. Doubtless more than one species has been included under the name *unicolorella.* There are almost certainly further species to be differentiated in the group allied to *E. elutella*; the females and even the males are structurally very similar, while the markings are liable to variation and effacement.

A female *Ephestia* from Beirut sent us by Count E. Turati belongs to this group but cannot at present be identified specifically. The forewings have no yellowish dorsal streak, the chitinised process of the eighth tergite is very blunt and the ductus bursae has no small chitinised spots; the lamina dentata is replaced by 4 chitinised plates. More material is required in order to clear up the systematics of the group.

E. elutella has so often been misidentified that the references to it in the literature are of very doubtful value. Generally speaking records of *E. cautella* are correct, but records of *E. elutella* may refer to either species. Unless the specimens are in good condition, identification by the genitalia is the only satisfactory method. *E. elutella* has been recorded from the following countries in addition to those from which we examined specimens :—

France (Laboulbène, 1864, etc.); Belgium (Crombrugghe de Picquendaele, 1906); Holland (Snellen, 1882); Sweden (Wallengren, 1871); Russia (Mokrzecki, 1916); Transcaucasia and Persia (Christoph, 1876); Asia Minor (Staudinger, 1879); Crete (Rebel, 1916*a*); Malta (Andres, 1916); Bulgaria (Tchorbadjef, 1929); Switzerland (Müller-Rutz, 1927); Egypt (Zeller, 1867*a*); S. Africa (Barrett, 1905); Madagascar (Ragonot and Hampson, 1901); Ceylon and Java (van Hall, 1914); Fiji (Meyrick, 1886); Hawaii (Meyrick, 1888); Canada (Curran, 1926); U.S.A. (Dyar, 1902); Panama (Dyar, 1914); Colombia (Ragonot and Hampson, 1901).

Records in the literature of the foods of the larva of *E. elutella* are often of doubtful value owing to the misidentification of the insect. *E. elutella* is one of the few species of *Ephestia* which is readily capable of maintaining itself out of doors in the European climate. Away from houses it may be attracted to sugar-traps (Jordheuille, 1883), while it often breeds in large numbers in thatch and haystacks (Barrett, 1905; Waters, 1929). In the latter situations it is supposed to feed on grass seeds and Zacher (1927*a*) has called it the Hay moth on account of this habit. Certain authors, Rössler (1880), Frey (1880), Hulst (1890), and Vorbrodt and Müller-Rutz (1914), state that the larva of *E. elutella* feeds in the open on rotten wood, and Forbes (1920) supposes, apparently on this account, that it is indigenous to the United States. While the latter statement is possibly true, there appears to be little good evidence for the former. It is unlikely that rotten wood is eaten at all.

Bruand (1847) notes that it attacks nuts while still on the tree. In warehouses, *E. elutella* is perhaps most serious as a pest of cacao (Munro and Thomson, 1929), but the complete list of recorded foods covers a very wide range. Cereals are rarely seriously attacked. Records from dried fruit perhaps often really refer to *E. cautella,* though it is by no means rare in dried fruit warehouses in London. The following foods have been recorded :—Currants (Büttner, 1880; Myers, 1928); dried grapes (Bruand, 1847); dates (Goureau, 1859; Laboulbène, 1864); prunes (Jordheuille, 1883; and personal observations); figs (Jordheuille, 1883); dried apples (Chittenden, 1897*a*); dried cherries (Rössler, 1880); dried hips and haws (Rössler, 1880); *Capsicum annuum* (Frivaldsky, 1895); dried rose petals (Rössler, 1880); dried pomegranate root (Laboulbène, 1864); Turkey Rhubarb root (Barrett, 1905; Zacher, 1927*a*); chicory (Prest, 1877); drugs—*Archangelica officinalis, Juni-*

perus communis, *Lavandula vera*, *Prunus spinosa*, *Rheum tanguticum* (van Emden, 1924, 1925*a*); dried mushrooms (Bruand, 1847); almonds (Laboulbène, 1864); walnuts (Maskew, 1920); ground-nuts (De Ong, 1925; Zacher, 1927*a*); cayenne pepper (Chittenden, 1897*a*); coffee (Goureau, 1859); biscuits (Bignell, 1894; Durrant, 1921); bread (Laboulbène, 1864; von Heinemann, 1865); in granaries (Jordheuille, 1883); in flour and stored grain (Mokrzecki, 1916); rice (Zacher, 1927*a*); seeds of sugar-beet (Rambousek, 1928); tobacco (Mokrzecki and Bragina, 1915; Tchorbadjef, 1929); dried vegetables (Zacher, 1927*a*); cacao (Munro and Thomson, 1929); nougat (Zacher, 1927*a*); leather (Laboulbène, 1864); dead insects (Gregson, 1873; Constant, 1866, etc.); honeycomb (Laboulbène, 1864). This last record we regard as very doubtful.

Zacher (1927*a*) has recorded some evidence as to the effect of different foods on the length of the life-history. He gives the following figures for the length of the most rapid developmental period :—on nougat, 58 days; on ground-nuts, 64 days; on hazel-nuts, 64 days; on bitter chocolate, 81 days; on almonds, 84 days. The period is of course very variable, and even on nougat some individuals took 182 days.

The following parasites and predators have been recorded :—*Microbracon hebetor*, Say, *Holepyris hawaiiensis*, Ashmd. (?), *Perisierola emigrata*, Rohw. (bred experimentally), *P. gallicola*, Kieff. (?), *Piczostethus flavipes*, Reut. (?).

E. disparella, Rag.

disparella. 1901 : Ragonot and Hampson, 298, pl. 34, fig. 25 (*Ephestia*); Staudinger and Rebel, 16. 1910 : von Caradja, 120. 1919 : Turati, 323. 1927 : Zerny, 133.
rectifasciella. 1913 : Turati, 18.

Forewings : near hair-brown, irrorated with white, especially near the costa : elongate, rather narrow, costa nearly straight, more curved towards the apex; 1st line before the middle, slightly oblique, somewhat curved towards the base of the wing near the costa, slightly darker than the ground-colour, inwardly margined with paler; 2nd straight, oblique towards the apex, inwardly margined with paler, this again margined inwardly with darker, relative positions of 1st and 2nd lines as in *E. elutella*, Hb.; 3rd hardly distinguishable; orbicular and claviform distinct. Hindwings : grey, narrowly margined with darker, cilia concolorous, with a darker subbasal line. M_{2+3} and Cu_{1a} shortly stalked, enclosing a short fork. Exp. ♂ 17, ♀ 15 mm.

♂. Forewing : dorsum above near the base with a small tuft of white, modified scales; when the costal fold is not expanded, the under surface of the fold is covered with not very long, grey hair-scales, and the ends of a few longer, whitish hair-scales protrude near the base. Hindwing : cubital pecten preceded near the base of the wing by a small area of white, semi-upright, spatulate scales; cubital pecten white, scarcely denser than that of the female; anal pecten dense white, preceded by a small tuft of white scales which are only slightly broader than those of the pecten.

♂. 8th tergite apparently as in *E. elutella*, Hb.

Genitalia : ♂. (Pl. VI, fig. 17.) As in *E. elutella*, Hb., but dorsal thickenings of the anellus not curved outwards at the apex, rather narrowly fused across the median line; gnathos diamond-shaped, posteriorly produced into arms which are as long as the body of the gnathos itself, the arms forming two sides of an equilateral triangle; aedeagus short and broad, as in *E. moebiusi*, Rebel.

♀. The genitalia of the single specimen we were able to examine were not in a condition to describe completely; the ductus bursae had a fairly large patch of densely placed, small chitinised spots, and the lamina dentata was replaced by 6 chitinised spots.

Specimens seen: Sardinia: 1 ♂, Aritzo, 6 July, coll. Turati; Canaries: 1 ♂, 1 ♀, Guimar, Teneriffe (*Walsingham*), ♂ 5, ♀ 14 April, '07. The specimen sent by Count E. Turati as his variety *rectifasciella* (Sardinia) proves to be identical with the Canary Island specimens. The species was described from Brussa, Asia Minor, and is further recorded from Kasikoparan (von Caradja) and Algeciras (Zerny).

E. parasitella, Stdgr.

parasitella. 1859: Staudinger, 226 (*Ephestia*). 1881: Staudinger, 88 (*Euzophera*). 1901: Ragonot and Hampson, 293, pl. 36, fig. 3 (*Ephestia*); Staudinger and Rebel, 16. 1910: Spuler, 202. 1927: Zerny, 133, *nec* Kirby (1884).

Forewings: light drab or drab-grey; elongate, costa nearly straight, more curved towards the apex; 1st line before the middle, nearly straight, moderately oblique towards the base of the wing; 2nd near the apex, proceeding from the tornus at right angles to the dorsum, but bending sharply towards the apex when approaching the costa, margined outwardly first with paler, then with darker; 3rd rather faint; orbicular moderately distinct, claviform usually connected to the dorsum by a dark shade. Hindwings: greyish-white, narrowly margined with darker, with a faint, darker, subbasal line in the greyish cilia. M_{2+3} and Cu_{1a} shortly stalked at base, enclosing a short fork. Exp. ♂ 15–20·5, av. 17·5, ♀ 16·5–19, av. 17·8 mm.

♂. Scale-tufts of hindwing and of 8th tergite as in *E. elutella*, Hb. Forewing: dorsum above with a tuft of scales at base; costal fold when unexpanded much like that of *E. cautella*, Wlk., with long grey hair-scales projecting at the apex. (None of our specimens has the costal fold expanded.)

Genitalia: ♂. (Pl. VI, fig. 19.) Very similar to *E. elutella*, Hb.; costa of valve with a subapical tooth (as in *E. woodiella*, sp. n.); dorsal thickenings of the anellus posteriorly produced inwardly into narrow processes which just fuse on the median line, outwardly, at a very obtuse angle, into broader lobes; gnathos subtriangular, anteriorly narrowly truncate, posteriorly produced into very short lateral arms.

♀. Very like *E. elutella*, Hb.; lamina dentata replaced by 10 chitinised plates; 7th sternite (Pl. X, fig. 84) usually with two more or less distinct rectangular areas which are more heavily chitinised than the rest of the sternite.

Specimens seen: France: 1 ♀, Cannes, bought from Staudinger; Sardinia: 1 ♂, Aritzo, 9 June, coll. Turati; Spain: 1 ♀, Andalusia, Ragonot Coll.; 2 ♂♂, Andalusia, 22 April '59, Staudinger, Zell. Coll.; 1 ♀, Vigo, June '86; Cyprus: 1 ♂, Platres, 5000–6000 ft., July '21, Hayward Coll.; Syria: 1 ♂, Leech Coll. The specimens obtained by Staudinger from Andalusia are perhaps paratypes. The specimen from Sardinia is darker than the others and the markings are nearly obsolete.

Besides the ♂ from Platres there was also a ♀ in which, however, the abdomen was missing; these two specimens are rather smaller, paler and less distinctly marked than the others of *E. parasitella*, Stdgr. Further, in the ♂, the gnathos is pointed anteriorly, and the dorsal thickenings of the anellus are posteriorly more broadly fused across the median line, and the outer lobes are broader. Until further material is forthcoming this can only be treated as an individual variation.

E. parasitella was described from Spain from moths bred from the parasitic plant, *Cytinus hypocistis*, L.

E. woodiella,[*] sp. n.

semirufa. 1859 : Stainton, 168 (*Ephestia*). 1875 : Barrett, 270. 1885 : Ragonot, 24. 1886 : Leech, 96, pl. 11, fig. 7. 1888 : Wood, J. H. 1890 : Hodgkinson (?). 1901 : Ragonot and Hampson, 302, pl. 35, fig. 13 (? in part only); Staudinger and Rebel, 16. 1905 : Barrett, 60, pl. 431, fig. 2. 1907 : Bankes. 1910 : Spuler, 202. 1928 : Meyrick, 387, *nec semirufa*, Haworth (1811, p. 496).
semirufella. 1872 : Morris, 115, pl. 79, fig. 20 (*Ephestia*).

Forewings : avellaneous, or greyer (light drab); elongate, but rather broader than in *E. elutella*, Hb., costa almost straight, less curved at the apex than in *E. elutella*, Hb.; 1st line rather before the middle, fairly straight, but more or less bisinuate near the costa, strongly oblique towards the base of the costa (more so than in *E. elutella*, Hb.), inwardly margined with paler; 2nd well beyond the middle, somewhat sinuate, approximately parallel to the termen, dark, very clearly margined inwardly with paler, this again clearly margined inwardly with darker; 1st and 2nd lines on the dorsum separated by a distance not greater than the length of the 1st line (in *E. elutella*, Hb., this distance is considerably greater); 3rd fairly distinct; orbicular and claviform distinct, except sometimes the latter. Hindwings : greyish, narrowly margined with darker, base of cilia usually paler than their apex. M_{2+3} and Cu_{1a} shortly stalked, enclosing a short fork. Exp. ♂ 16·5–19, ♀ 15–16·5, av. 15·7 mm.

♂. Forewing : dorsum above near the base with a small tuft of yellowish modified scales; when the costal fold is not expanded, the ends of a few whitish, spatulate hair-scales protrude at its base, and long grey hair-scales at its apex. Hindwing : as in *E. elutella*, Hb.

♂. 8th tergite as in *E. elutella*, Hb.

Genitalia : ♂. (Pl. VI, fig. 20.) Similar to *E. elutella*, Hb., but costa of valve (Pl. VIII, fig. 59) with a median tooth; dorsal thickenings of anellus less curved posteriorly, and produced narrowly inwards so as just to fuse on the median line.

♀. Resembles *E. elutella*, Hb., but the chitinised area of the 8th tergite (Pl. X, fig. 82) is produced into a much broader, rounded process; lamina dentata replaced by 9 chitinised plates.

A form of *E. woodiella* occurs in several parts of Italy. The wing-markings of the Italian specimens are scarcely distinguishable from those of *E. elutella*, Hb., the position of the 1st and 2nd lines being variable. The male genitalia resemble those of the English form, except that the dorsal thickenings of the anellus are not always produced inwards and do not fuse on the median line. In the female, the 8th tergite is little chitinised, though the central chitinised lobe, when visible, is blunt as in the English form; the ductus bursae has fewer and smaller chitinised spots, so as sometimes to appear almost membranous; the plates in the walls of the bursa are longer than in *E. elutella* and more numerous (9–17, average, 12). Without more biological information as to these forms they are best treated together.

Specimens seen : BRITISH ISLES : 1 ♂, Lewisham, Kent, 22 May '48, Stainton Coll.; 3 ♀♀, Tarrington, Hereford, '90 (*J. H. Wood*), Banks Coll.; ITALY : Reggio Emilia, 1 ♀ 13 Aug. '26, 1 ♂ July '29; Appenn. Moden., Sestola, 1 ♀ 23 July '20, 1 ♂ 8 July '22; Benaco, Gardone Riviera, 1 ♀ 3 Aug. '30, 4 ♀♀ 7 Aug. '30, 4 ♀♀ 23 Aug. '30, 2 ♀♀ 25 Aug. '30; 1 ♀, Acqui, 17 June '03; 1 ♀, S. Remo, 20 April '03; 1 ♀, no data—Turati.

In the British Museum Coll. there are the following further specimens, of which we did not examine the genitalia, but (judging by the markings) are certainly *E. woodiella*: in the Banks Coll., 5 additional specimens from Tarrington, 1 from Teignmouth, Devon (*Dr. Jordan*) (specimen referred to by Barrett (1875, p. 270); 2 specimens, Barrett, '06, no locality. In the British Coll. at the Brit. Mus. there are also many specimens of *E. elutella* misidentified as *E. semirufa* (i.e. *woodiella*).

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[*] It is possible that this species is identical with *E. vitivora*, Filipjev (1931). Filipjev's account and figures of the male are very suggestive of *E. woodiella*, except that the 8th tergite is stated to have only two tufts on each side. In the female the lamina dentata is said to be represented by fewer plates than in *E. elutella*, Hb.

Haworth (1811) described a *Phycis semirufa* which from the description was probably only one of the common varieties of *E. elutella*, Hb., in which the dorsal half of the wings is conspicuously reddish. Haworth's type appears to be lost. Stainton (1859) applied the name to a distinct species, not at all agreeing with Haworth's description and later authors have followed him. The correct course seems to us to describe Stainton's species as new, since it is quite distinct from any of the species we have been able to examine. Ragonot and Hampson (1901) under the name "*semirufa*" describe a form in which the male is said to lack a costal fold and tuft on the forewings. If the specimens Ragonot examined were really males they must belong to an undescribed species. Ragonot also received from Frey two males (presumably from Switzerland) which he believed to be his *semirufa*. These males had costal tufts.

In England *E. woodiella* has been recorded from a number of southern and western localities, always remaining scarce and local. Wood (1888) has given some notes on the life-history. In Sept. 1886 he caught a single female which was attracted to light in his room. The larvae which hatched from the eggs laid were bred on nut-kernels. They pupated in the following May and the moths emerged in June. As ivy (*Hedera helix*) was growing just outside his window, Wood thought that the larvae might feed on its berries, though it was equally likely that they would feed on refuse. Laboulbène (1864) records ivy-berries as the food of *E. elutella*, and it is conceivable that these specimens were really *E. woodiella*. Adults of *E. woodiella* are always captured out of doors, but the real food of the larva is not known.

E. colorella, Dyar.

colorella. 1914: Dyar, 345 (*Ephestia*).

Forewings: wood- or hair-brown, costa nearly straight; 1st line slightly before the middle, straight, oblique towards the base of the costa, white; the area between this line and the base of the wing vinaceous-buff; 2nd nearer the apex than the middle, straight, parallel to the termen, white, preceded on the costa by a small pale suffusion; the area between the 1st and 2nd lines darker than the rest of the wing; 3rd absent; stigmata absent. Hindwings: whitish-grey, narrowly margined with darker, more broadly so near the tornus, veins also darker, cilia whitish-grey with a darker subbasal line. M_{2+3} and Cu_{1a} very shortly stalked, enclosing a moderately long fork. Exp. ♂♀ 11·5 mm.

♂. Forewing: dorsum above with no tuft of modified scales at base; base of costa deflected. When the costal fold is not expanded a large tuft of long, white, pink-tipped scales protrude at the apex. Hindwing: costal margin with yellow scales along its basal half; no tuft of yellowish scales preceding the anal pecten; only the anal pecten moderately dense, yellowish, the hairs short, spatulate.

♂. 8th tergite (Pl. VIII, fig. 43) almost entirely membranous, with a narrow central chitinised strip; on each side of the tergite anteriorly arise four tufts of modified scales; of these tufts three arise from two transverse chitinised plates, and the fourth from a plate placed almost longitudinally. The outermost tuft is much broader than the others, one of which is strongly curved towards the median line.

Genitalia: ♂. (Pl. VII, fig. 36.) The membranous area of the saccus covering a little more than half its width; costa of valve without a tooth; ventral thickenings of the anellus consisting of a large, elongate-triangular lobe on each side, dorsal thickenings small, triangular, their inner angles sharp; gnathos not present as a single median structure; each strut bears a large, posteriorly directed process whose apex is bent inwards into a sharp hook, the apex of the aedeagus passing between these hooks; subscaphium not transversely striate; uncus broadly truncate; tegumen laterally produced into short, rounded lobes; aedeagus a simple, subcylindrical tube, somewhat expanded at the apex; chitinised area of the vesica about two-fifths the length of the aedeagus and about five times as long as broad.

♀. (Pl. IX, fig. 78.) Ovipositor bluntly rounded; in the one specimen we have been able to examine it is bent downwards so that its apex points anteriorly, its struts 1½ times the width of the 8th tergite, which is a little longer than broad, evenly chitinised throughout; ductus bursae evenly chitinised for the greater part of its length, posteriorly somewhat expanded and thrown into longitudinal folds; bursa (Pl. IX, fig. 77) with no small chitinised spots in its wall, lamina dentata with two rows of 5 long teeth; an almost crescentic chitinised area lies in the membrane between the ostium and the 8th sternite (Pl. IX, fig. 79).

Specimens seen: PANAMA: 1 ♂, 1 ♀, Taboga Island, 12th Feb. (*A. Busck*), U.S. Nat. Mus.

Dyar described his species from Panama; the specimens we examined are paratypes.

E. afflatella, Mn.

afflatella. 1855: Mann, 559 (*Myelois*). 1886: Millière, 85 (*Ephestia*). 1901: Ragonot and Hampson, 284, pl. 34, fig. 16; Staudinger and Rebel, 15. 1910: Spuler, 202; von Caradja, 120. 1924: Turati, 132. 1927: Vecchi, 50.
reductella. 1864: Mann, 182, pl. 4, fig. 6 (*Ephestia*). 1879: Staudinger, 228. 1901: Ragonot and Hampson, 286, pl. 34, fig. 18; Staudinger and Rebel, 15.
clothella. 1875: Millière, 62 (*Myelois*).
philemonella. 1875: Millière, 63 (*Myelois*).

Forewings: grey, sometimes with a reddish tinge (vinaceous-buff), sometimes untinged (drab-grey or light drab); elongate, costa only very slightly curved; 1st line rather before the middle, nearly straight, slightly curved inwards at the costa, not much darker than the ground-colour, inwardly margined with paler, the pale almost interrupting the line at a point halfway between the costa and the disc; 2nd very faint or absent; 3rd consisting of a series of very faint dots, or absent; orbicular faint or absent, claviform absent. Hindwings: greyish-white, margined with grey, cilia usually with a faint grey subbasal line. M_{2+3} and Cu_{1a} approximated at base, enclosing a long fork. Exp. ♂ ♀ 20–22 mm.

♂. Forewing: dorsum above with no tuft of modified scales; base of costa deflected, enclosing numerous short, white scales at the base, an apical tuft consisting partly of similar scales, partly of long, hair-like, greyish ones, and between them an agglomeration of curved, twisted scales. These scales are all shorter than those of *E. figulilella*, Gregs.; when not expanded, the protruding ends of long, whitish hair-scales are seen at the base, and those of grey ones at the apex, the apical tuft appearing to be about one-third the length of the fold. Hindwing: no area of yellow scales anteriorly to the cubital pecten; only the anal pecten dense, yellowish, preceded by a small tuft of broad, yellowish scales.

♂. 8th tergite as in *E. cautella*, Wlk.

Genitalia: ♂. (Pl. VI, fig. 24 and 25.) The membranous area of the saccus covering about one-half of its width; costa of valve produced into a moderately long, subapical tooth tapering to the apex; ventral thickenings of anellus produced into two lobes on each side; dorsal thickenings large, produced into a finger-shaped outer lobe and a large, rounded-rectangular inner one; gnathos strongly transverse, with short lateral arms; striations of subscaphium scarcely developed; apex of uncus broadly truncate; tegumen laterally produced into long processes which are curved and pointed at the apex; aedeagus somewhat expanded at the apex; chitinised area of vesica of moderate size.

There appears to be some variation in the exact shape of the dorsal thickenings of the anellus and of the sacculus (see fig. 25).

♀. (Pl. IX, fig. 74.) Ovipositor bluntly rounded; 8th tergite fully twice as broad as long, evenly chitinised; ductus bursae with a broad band of tooth-bearing chitinised spots spirally encircling it, the spots at the edges of the band being enlarged; bursa (Pl. IX, fig. 76) with no small, chitinised spots in its wall, the lamina dentata replaced by three chitinised plates; membrane between the 7th and 8th sternites (Pl. IX, fig. 75) on each side with a narrow chitinised strip, bearing an easily-detached tuft of modified scales.

Specimens seen: In the collections we studied a few specimens of *E. afflatella*, Mn., were misidentified as *E. calidella*, Gn., *cautella*, Wlk., and *figulilella*, Gregs. We have examined the genitalia of the following specimens: France: 1 ♀, S. France, Coll. Ragonot; Corsica: 2 ♂♂ (*Mann*), Zell. Coll., one Aug., one Sept. '55; Italy: 2 ♂♂, 2 ♀♀, Reggio Emilio; 1 ♂, Rome; 1 ♀, Sicily, Coll. Turati; Asia Minor: 1 ♂, Brussa, '69 (*Mann*), Zell. Coll.; 1 ♂, 2 ♀♀, Syria, Leech Coll.; Turkey (see below).

We can find no structural difference between a ♀ (Turkey, '64 (*Mann*), Zell. Coll.) labelled *E. reductella*, Mn., and ordinary *afflatella*, Mn. The markings are somewhat more reduced, but there is little doubt that the names should be treated as synonymous.

Spuler (1910) and Vecchi (1927) record that the larva lives in dried fruit, and Ragonot and Hampson (1901) state that Millière reared the larva on raspberries and medlars, while Constant found the larva inside grapes.

E. figulilella, Gregs.

figulilella. 1871: Gregson (*Ephestia*). 1885: Ragonot, 25. 1901: Ragonot and Hampson, 282, pl. 34, fig. 14. 1902: Dyar, 435. 1910: von Caradja, 120; Spuler, 202. 1922: Turati and Zanon, 164. 1924: Turati.
ficulella. 1875: Barrett, 271 (*Ephestia*). 1880: Meyrick, 234. 1886: Leech, 95, pl. 11, fig. 6. 1897: Chittenden, *a*, 10. 1901: Staudinger and Rebel, 15. 1905: Barrett, 52, pl. 430, fig. 4. 1925: Graves, 100. 1928: Meyrick, 388.
milleri. 1876: Zeller, 339 (*Ephestia*). 1890: Druce, 287.
desuetella. 1887: Meyrick, 265 (*Ephestia*). 1888: Meyrick, 244. 1890: South, 303, pl. 3, fig. 5. 1893: Riley, *a* (?), *nec* Walker.
kühniella. 1893: Riley, *b* (*Ephestia*), *nec* Zeller.
figuliella. 1920: Forbes, 635 (*Ephestia*).
figulella. 1926: Curran, 386, fig. 4 (*Ephestia*).
venosella. 1926: Turati, 58, fig. 19 (*Ephestia*).
ernestinella. 1927: Turati, 330, fig. 7 (*Ephestia*).

Forewings: light drab, rarely drab or drab-grey, sometimes yellower (avellaneous, vinaceous-buff); elongate, narrow, the costa basally nearly straight, slightly curved towards the apex; markings nearly always very obscure, the 1st line before the middle, nearly straight, slightly curved inwards at the costa, not much darker than the ground-colour, inwardly obscurely margined with paler; 2nd beyond the middle, faint or absent, a pale border on its inner side often rather more distinct; 3rd faint; orbicular faint or absent, claviform absent. Hindwings: whitish, with a narrow, yellowish-grey border, cilia white. M_{2+3} and Cu_{1a} approximated at base, enclosing a long fork. Exp. ♂ 14–19·5, av. 16·1, ♀ 13–19, av. 16·0 mm.

♂. Forewing (Pl. V, fig. 10): dorsum above with no tuft of scales near base; base of costa deflected, enclosing a tuft of very long hair-scales at the base and one of still longer ones at the apex, and between them an agglomeration of curved, twisted scales. When the costal fold is not expanded, some long hairs protrude at the base and a very long procumbent tuft, as long as the whole fold, protrudes from the apex and lies along the surface of the wing towards whose apex it is directed. Hindwings: no area of yellow scales in front of the cubital pecten; only the anal pecten dense and yellowish, preceded by a tuft of broader, yellowish, scales.

♂. 8th tergite as in *E. cautella*, Wlk.

Genitalia. (Pl. VI, fig. 22.) The membranous area of the saccus covering about half its width or rather less; costa of valve (Pl. VIII, fig. 53) produced into a long, parallel-sided, subapical tooth; dorsal thickenings of the anellus much longer than broad, produced posteriorly into two narrow lobes, an outer one ending in a small knob, and a longer, simple inner one; gnathos broader than long, with long lateral arms; subscaphium hardly chitinised, not transversely striate; apex of uncus rounded; tegumen laterally produced into broad, pointed lobes; aedeagus (Pl. VIII, fig. 52) a simple, subcylindrical tube; chitinised area of vesica of moderate size.

♀. (Pl. IX, fig. 68.) Ovipositor bluntly rounded; 8th tergite nearly twice as broad as long, evenly chitinised; ductus bursae with two rows of chitinised spots spirally encircling it; bursa (Pl. IX, fig. 70) with a dense patch of tooth-bearing chitinised spots at its anterior end, the lamina dentata replaced by 4–7 spindle-shaped chitinised plates; a large, firmly-attached fan of modified scales arises on each side of the ostium from a narrow chitinised strip in the membrane between the 7th and 8th sternites (Pl. IX, fig. 69).

Specimens seen: Owing to its obscure markings *E. figulilella*, Gregs., appears to be rather often confused with other species, e.g. *E. cautella*, Wlk., *calidella*, Gn., while amongst the series of supposed *figulilella* were specimens of *E. kühniella*, Zell., *afflatella*, Mn., and *cautella*, Wlk. The following records are based on specimens whose genitalia we have examined: BRITISH ISLES: 1 ♂, London '90 (*A. Griffith*), Banks Coll.; 1 ♀, London, 8 Oct., Stainton Coll.; 1 ♀, London, Dec. '74, Zell. Coll.; London, bred from dates, 5 June '28, the authors; 1 ♂, 1 ♀, no locality, Crowley Bequest; 2 ♂♂, 2 ♀♀, Britain, Sheppard Coll. numerous specimens, dried fruit warehouse, London, Sept. '29 (*W. S. Thomson*); CENTRAL EUROPE: 1 ♂, no locality, Zell. Coll., determined as *E. milleri*, Zell.; W. AFRICA: 1 ♀, Bathurst, Gambia, Nov. '85 (*Carter*); ALGERIA: 1 ♂, Biskra, 16 April '03 (*Walsingham*); CYRENAICA: 3 ♂♂, coll. Turati; SYRIA: 1 ♀, Leech Coll.; PERSIA: 1 ♀, Asterabad, Feb. '70 (*Lederer*), Zell. Coll.; INDIA: 1 ♀, Deesa, June '97 (*Nurse*); CEYLON: 1 ♀, Puttalam, '01.

In the Zeller Collection at the British Museum several specimens identified by Zeller as *E. milleri*, Zell., prove that that species is synonymous with *E. figulilella*, Gregs.

Count E. Turati kindly sent us specimens of his two species *E. venosella* and *E. ernestinella*. Both must be regarded as forms of *E. figulilella*, but *E. ernestinella* is a remarkable variety in which the forewings are uniformly pale ochraceous buff.

The species was described by Gregson from Liverpool and besides the localities from which we have seen specimens it has been recorded from the following countries:—Madeira (Alphéraky, 1883); Hawaii (Meyrick, 1888); Australia (Meyrick, 1880, 1888); Canada (Curran, 1926); U.S.A. (Forbes, 1920); Trinidad (Knapp, 1921); Colombia (Ragonot and Hampson, 1901).

Little has been recorded of the habits of *E. figulilella*, which is always considerably less common than *E. elutella* and *E. cautella*, although it feeds on the same type of foods, of which the following have been recorded:—Currants (Barrett, 1875); figs (Barrett, 1875; Gregson, 1871); raisins (Gregson, 1871); cotton-seed cake (Atmore, 1884); oatmeal (Chittenden, 1897*a*); rice meal (Nagel, 1908); in a cacao store (Knapp, 1921; 1923); in a chemist's shop

(Meyrick, 1880). We have found it rather uncommonly in two dried fruit warehouses in London.

E. calidella, Gn.

calidella. 1845 : Guenée, *a*, 82; *b*, 320 (*Ephestia*). 1885 : Ragonot, 24. 1901 : Ragonot and Hampson, 281, pl. 34, fig. 24; Staudinger and Rebel, 15. 1905 : Barrett, 5, pl. 430, figs. 3, 3 *a*, 3 *b*. 1910 : von Caradja, 119; Spuler, 202. 1914 : Vorbrodt and Müller-Rutz, 310. 1922 : Turati and Zanon, 164. 1928 : Meyrick, 389.
ficella. 1851 : Douglas (nomen nudum) (*Ephestia*). 1859 : Stainton, 169 (*Ephestia*). 1872 : Morris, 115, pl. 79, fig. 19. 1875 : Barrett, 270; Millière, 266. 1878 : Berce, 356. 1879 : Staudinger, 228. 1886 : Leech, 95, pl. 11, fig. 5.
xanthotricha. 1859 : Staudinger, 226 (*Ephestia*). 1879 : Staudinger, 226. 1882 : Nolcken, 518.
gnidiella. 1882 : Nolcken, 182 (*Ephestia*) *nec* Millière.
bengasiella. 1924 : Turati, 132, pl. 5, fig. 19 (*Ephestia*).
Misspelling : *callidella.* 1883 : Alphéraky, 231 (*Ephestia*).

Forewings : usually light drab, rarely paler, sometimes darker to drab, or more brown (avellaneous to wood-brown); elongate, costa distinctly curved, especially towards the apex; 1st line rather before the middle, straight, bisinuate on the disc, dark, inwardly broadly edged with whitish; 2nd oblique towards the apex, sinuate inwardly before the costa; 3rd consisting of a series of small dark spots; orbicular usually faint or absent, claviform nearly always absent. Hindwings : white, narrowly margined with grey, cilia white. M_{2+3} and Cu_{1a} approximated at base, enclosing a long fork. Exp. ♂ 17–20·5, av. 19·5, ♀ 20–24, av. 22·7 mm.

♂. Forewing : dorsum above with no tuft of modified scales; base of costa deflected, enclosing an area with the following groups of modified scales : a basal tuft of hair-scales, an apical tuft of longer ones, and between them an agglomeration of curved, twisted hair-scales. These tufts are all shorter than those of *E. figulilella*, Gregs. When the costal fold is not expanded, the ends of long, whitish hair-scales protrude at the base and at the apex, the apical tuft appearing to be about a quarter the length of the fold. Hindwing : no area of yellow scales anteriorly to the cubital pecten, only the anal pecten dense, yellowish, preceded by a small tuft of broad, yellowish scales.

♂. 8th tergite as in *E. cautella*, Wlk.

Genitalia : ♂. (Pl. VI, fig. 23.) The membranous area of the saccus covering only a quarter of its width; costa of valve (Pl. VIII, fig. 58) produced into a long, subapical tooth tapering to the apex; dorsal thickenings of the anellus large, produced into a nearly semicircular outer lobe and a small rectangular inner one, fused across the median line; gnathos very broad, with long lateral processes; anal tube very broad, subscaphium strongly and transversely striate; apex of uncus slightly emarginate; tegumen laterally produced into finger-shaped lobes; aedeagus (Pl. VIII, fig. 57) a simple, subcylindrical tube; chitinised area of vesica of moderate size.

♀. (Pl. IX, fig. 66.) Ovipositor bluntly rounded; 8th tergite broader than long, with a large, membranous apical area, leaving only a narrow posterior chitinised strip on the disc; ductus bursae with a striate plate which becomes broader in the direction of the bursa; bursa (Pl. IX, fig. 65) with numerous small chitinised spots in the region of the ductus, the lamina dentata replaced by a group of 4–11 (usually 6–8) chitinised plates; 7th sternite (Pl. IX, fig. 67) reflexed over the ostium to form an operculum.

Specimens seen : *E. cautella*, Wlk., and especially *E. figulilella*, Gregs., have been much confused with *E. calidella*, Gn., in the collections we have studied. We have examined the genitalia of the following specimens : British Isles : 1 ♂, London, '90 (*A. Griffith*); 1 ♀, no loc. '05 (*P. Mason*); 1 ♀, April '68 (*Doubleday*), Zell. Coll.; Asia Minor : 1 ♀, "Hyrc." (? Hyrcanian Mountains), 12 Sept. '76, Zell. Coll.; 1 ♀, Palestine; Egypt : 1 ♀, Behria Oasis, 22 Feb. '30, emerged 26 Mar. '30 (*R. Attia*); Dalmatia : 1 ♂, Frey

Coll.; 1 ♂, Ragonot Coll.; Spain: 1 ♀, Andalusia; Cyrenaica: 1 ♀, Bengasi, 20 April, coll. Turati; Canaries: 2 ♀♀, Guimar, Teneriffe (*Walsingham*), one, 16 April '07, the other, 28 March '07; 1 ♀, Teneriffe, '04 (*W. White*). Further, we have seen two specimens, 1 ♂, Zell. Coll. and 1 ♀, Frey Coll., of which the place of capture is not recorded. In the Banks Collection there are 18 more specimens of *E. calidella*, Gn., probably correctly identified; these were undoubtedly captured in England, but have no precise data.

Count E. Turati kindly sent us a specimen of his *E. bengasiella*, which proves to be a variety of *E. calidella* in which the forewings are uniformly pale ochraceous buff, without markings.

In addition to the countries from which we have seen specimens, the following localities have been recorded:—Mesopotamia (Buxton, 1920); Greece (Staudinger, 1879); Dalmatia (Staudinger, 1879); Sicily (De Stefani, 1919*a*); Austria (Ragonot and Hampson, 1901); Germany (Büttner, 1880; Kräpelin, 1900); Switzerland (Vorbrodt and Müller-Rutz, 1914); France (Guenée, 1845*a*, etc.); Spain (Ragonot and Hampson, 1901); Algeria (von Caradja, 1910).

E. calidella, Gn., is essentially a pest of fruit and in this capacity it is occasionally troublesome in the Mediterranean region, *e.g.* on dates in Egypt. Other products, such as nuts and locust beans (*Ceratonia*) are occasionally attacked. In more northern countries it is too rare to be more than an infrequent pest; possibly the winters are too cold for it. The following foods have been recorded:—Figs (Douglas, 1851); currants (Büttner, 1880); raisins (Barrett, 1905); dates (Gough, 1918; Buxton, 1920); berries of *Mespilus japonicus* (Nolcken, 1882); Ceratonia beans (De Stefani, 1919*a*); almonds (Barrett, 1905); cork (Barrett, 1875; Kräpelin, 1900); dried insects (Alphéraky, 1883).

The only recorded parasite is the Chalcid, *Dibrachys cavus*, Walk. (*boucheanus*, Nees) (De Stefani, 1919*b*).

E. cautella, Wlk.

cautella. 1863: Walker, 73 (*Pempelia*). 1889: Cotes and Swinhoe, 675 (*Salebria*). 1896: Hampson, 66 (*Ephestia*). 1901: Ragonot and Hampson, 292, pl. 34, fig. 23; Staudinger and Rebel, 16. 1902: Dyar, 435. 1910: Spuler, 202. 1913: Durrant and Beveridge, 615. 1914: Vorbrodt and Müller-Rutz, 310. 1915: Mason *; Parker, 283, fig. 2. 1920: Fletcher and Ghosh, 715. 1925: Leefmans, figs. 1926: Curran, 386, fig. 3. 1928: Meyrick, 388; Myers, 11; Shibuya, 18 and 77. 1930: Richards and Herford, 380, pl. 30, fig. 40, pl. 31, fig. 45.
defectella. 1864: Walker, 962 (*Cadra*).
desuetella. 1866: Walker, 1719 (*Nephopteryx*).
cahiritella. 1867: Zeller, *a*, 384 (*Ephestia*); *c*, 466, pl. 24, fig. 7. 1890: South, 304, pl. 4, fig. 12. 1904: van Deventer, 80, pl. 9, fig. 2 *a*, *b* and *c*. 1905: Barrett, 56, pl. 430, figs. 6, 6 *a*, 6 *b*.
passulella. 1875: Barrett, 271 (*Ephestia*). 1885: Ragonot, 24. 1886: Leech, 95, pl. 11, fig. 4.
formosella. 1918: Wileman and South, 219 (*Cryptoblabes*) male but not female according to Shibuya (1928).

Common names:—The dried currant moth; the fig moth.

Forewings: light drab, sometimes darker (drab), or with less yellow (drab-grey, mouse-grey), or browner (wood-brown, hair-brown), or yellower (avellaneous, various shades of buff); elongate, costa straight at base, rather strongly curved at apex; 1st line rather before the middle, very slightly curved inwards towards the costa, the line itself usually rather faint, but the whitish suffusion bordering its inner margin usually well marked; 2nd faint (sometimes absent), usually bordered inwardly with paler, this again sometimes margined inwardly with darker; 3rd faint or absent; orbicular faint or absent, claviform absent. Hindwings: whitish or greyish, narrowly margined with grey, cilia usually with a well-marked, dark subbasal line. M_{2+3} and Cu_{1a} approximated at base, enclosing a long fork. Exp. ♂ 11–17·5, av. 13·7, ♀ 12–20, av. 16·1 mm.

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* Mason (1915) in his report merely refers to a "Pyralid larva." In the abstract of his paper in 1915, *Rev. Appl. Ent.*, **4** (A): 67, this is identified as *E. elutella*, Hb. On the identification files of the Imperial Bureau (now Institute) of Entomology, however, the specimens were recorded as *E. cautella*, Wlk., which was probably correct. There is no record of *E. elutella* as yet from E. Africa.

♂. Forewing (Pl. V, fig. 11): dorsum above with no tuft of modified scales; base of costa deflected, enclosing very long, pale greyish hairs, densely placed throughout. When the costal fold is not expanded, long hairs protrude right along its margin, making the fold appear very wide. Hindwing: no area of yellowish scales anteriorly to the cubital pecten; only the anal pecten dense, yellowish, preceded by a small tuft of broad, yellowish scales.

♂. 8th tergite (Pl. VIII, fig. 39) largely membranous, with a moderately broad apical area which is produced anteriorly into a narrow central strip, more chitinised, the central strip ending in a small, rounded expansion; on each side of the tergite anteriorly arise five tufts of modified scales; one of the tufts is less dense, and projects anteriorly (when the apical segments of the abdomen are fully exserted); of the others, which are directed posteriorly, three are of about the same length, and one about one-third longer; there is further a median, anteriorly-directed tuft of hair-scales arising from the membrane between the 7th and 8th tergites.

Genitalia: ♂. (Pl. VI, fig. 21.) The membranous area of the saccus covering about one-half its width; costa of valve (Pl. VIII, fig. 51) produced into a short, tapering, subapical tooth; dorsal thickenings of the anellus produced into a large, oval outer lobe and a smaller, finger-shaped inner one; gnathos about as long as broad, with long lateral arms; subscaphium weakly chitinised, not striate; apex of uncus rounded; tegumen laterally produced into finger-shaped processes; aedeagus (Pl. VIII, fig. 50) a simple, subcylindrical tube; chitinised area of vesica of moderate size.

♀. (Pl. IX, fig. 63.) Ovipositor bluntly rounded; 8th tergite twice as broad as long, with a large, membranous apical area, leaving only a narrow posterior chitinised strip on the disc, this strip often produced on the median line into a small, tooth-like process; ductus bursae with a parallel-sided, striate plate; bursa (Pl. IX, fig. 64) with numerous small chitinised spots at the posterior end, the lamina dentata replaced by 1 to 5 (usually 2 to 3) chitinised plates.

Specimens seen: In the collections we studied a few specimens of *E. cautella*, Wlk., were misidentified as *E. calidella*, Gn., and *E. figulilella*, Gregs. Worn specimens of other species appear to be identified frequently as *E. cautella*, Wlk., e.g. *E. afflatella*, Mn., *elutella*, Hb., and *figulilella*, Gregs., also worn specimens of allied genera. Where our material consisted of a number of specimens from one locality, we examined the genitalia of two or three only, and it is on the latter that the following records are based: BRITISH ISLES: 2 ♀♀, London, Dec. '74 (*Barrett*), Zell. Coll.; London, numerous specimens from docks and warehouses (*Richards and Herford*) (1930); ITALY: Reggio Emilia, 17 Oct. '23 (*Turati*); SPAIN: 1 ♀, Malaga, 5 May '01 (*Walsingham*); SOUTH AFRICA: 1 ♀, Ceres, Cape Prov., Mar. '25 (*R. E. Turner*); 1 ♀, Port St. John, Pondoland, Jan. '24 (*R. E. Turner*); 2 ♀♀, Durban, Natal (*G. F. Leigh*), one, Dec. '01, one bred, 20 Aug. '01; EAST AFRICA: 1 ♂, Mombasa, June '93 (*P. de la Garde*); 1 ♀, Teita, 2500–3000 ft., Jan. '92 (*F. J. Jackson*); 1 ♂, Inhambane, north of Delagoa Bay, 11 Aug. '99 (*E. M. de Jersey*); 1 ♂, 1 ♀, Mt. Mlanje, Nyasaland (*S. A. Neave*), ♂ 12 Jan. '13, ♀ 17 Dec. '12; 1 ♀, Chinde, Nyasaland, 6 Aug. '99 (*E. M. de Jersey*); WEST AFRICA: 1 ♂, Kumasi, Gold Coast (*J. D. G. Sanders*); CANARIES: 1 ♂, on board S.S. Gando, off Las Palmas, 19 June '07 (*Walsingham*); 1 ♂, 1 ♀, S. Cruz, Teneriffe (*Walsingham*), ♂ 17 Jan. '07, ♀ 18 Jan. '07; ALGERIA: 1 ♂, 3 ♀♀, Biskra (*Walsingham*), ♂ 8 April '03, 2 ♀♀ 13 April '03, 1 ♀ 16 May '03; 2 ♀♀, Hamman-es-Salahain (*Walsingham*), one, fruit, 24 Mar. '04, the other, dates, 11 April '04; EGYPT: 1 ♀, Aswan, 8 April '21 (*Capt. J. K. Hayward*); 2 ♂♂, 2 ♀♀, Cairo, Oct.–Nov. '29 (*R. Attia*); MESOPOTAMIA: 1 ♂, Basra, Nov. '18 (*P. J. Barraud*); ARABIA: 1 ♂, Aden, May '00 (*P. de la Garde*); PERSIA: 1 ♂, Asterabad, Jan. '70 (*Lederer*), Zell. Coll.; S. RUSSIA: 1 ♂, Lenkoran, Azerbaijan, '71 (*Christ.*), Zell. Coll.; INDIA: 1 ♂, Patna, Bengal, 6 July '11, dried poppy petals; 1 ♂, Bihar, Pusa, Bengal, July '10, rice-grain store; 1 ♀, Pusa, 10 Dec. '12, on arhar dal in store; 1 ♂, Pusa, 2 July '09, almonds in store; 1 ♀, Bay of Bengal, at sea, 21 Jan. '08 (*G. Meade-Waldo*); 1 ♀, Bhutan, Nov. '94; 1 ♂, 1 ♀, Kashmir, 16 Nov. '17, on olive fruits; 1 ♀, Srinagar, Kashmir, 5200 ft., 8 Sept. '23, Fletcher Coll.; 1 ♂, Muktesar, Kumaon, 7500 ft., 11 Sept. '22, Fletcher Coll.; 1 ♀, Coorg, Merkara, 15–20 Oct. '15, Fletcher Coll.; 1 ♀, Coimbatore, Madras, 24 Feb. '13; CEYLON: Types of *cautella*, Wlk., *defectella*, Wlk.; 1 ♂, groceries, '02; 1 ♀, Peradeniya, Mar. '01, cake chocolate; 1 ♂, Maskeliya, Aug. (*J. Pole*); 1 ♀, Taldeniya, 10 Dec. '19, bred cacao-beans (*J. C. Hutson*); 1 ♂, Colombo, Dec. '02, Mackwood Coll.; 1 ♀, Puttalam, Mackwood Coll.; 1 ♂, Matele, Deca; BURMA: 1 ♀, Tuaton, 1 Mar. '18; COCHIN CHINA: 2 ♀♀, Iatapuram, 20 April '23; CHINA: 1 ♂, Ichang, Aug. '88 (*Mrs. Pratt*), Leech Coll.; 1 ♀, Chungking, Oct. '12, B. Barry; FORMOSA: 1 ♂, Tainan, 17 Nov. '05 (*A. E. Wileman*); JAPAN: 1 ♀ (*H. Pryer*), Leech Coll.; JAVA: 1 ♀, bred imported chocolate bonbons (*S. Leefmans*); 1 ♂, 1 ♀, Buitenzorg, Feb. '19 (*W. Roepke*); SAMBAWA: 1 ♂, 1 ♀, Sept. '19 (*Doherty*); SARAWAK: 1 ♀, Sanders Coll.; PHILIPPINES: 1 ♀, Manila (*Banks*); HAWAII: 1 ♀, prior to 1877; TAHITI: 1 ♂, Papeete, 31 Mar. '03, on board R.Y.S. Valhalla (*Nicoll*); CANADA: 1 ♀, Vancouver, 5 Sept. '18 (*J. H. Turner*); MEXICO: 1 ♀, Presidio, Forrer, Godman-Salvin Coll.; BAHAMAS: 1 ♂, Nassau, 2 June '98 (*J. L. Bonhote*); JAMAICA: 2 ♂♂, St. Anne, '92, in fruit of *Quinia jamaicensis* (*T. D. A. Cockerell*); 1 ♀, Runaway Bay, Mar. '05 (*Walsingham*); GRAND CAYMAN: 1 ♀, on R.Y.S. Valhalla, 10 Mar. '02 (*Nicoll*); PORTO RICO: 1 ♀, on R.Y.S. Valhalla, 23 Feb. '04 (*Nicoll*); COLOMBIA: 1 ♀, Jimenez, W. Colombia, 1600 ft., Feb. '07; ECUADOR: 1 ♂, Bogota, 13 Mar. Zell. Coll.; CHILE: 1 ♀, Coquimbo (*Walker*); URUGUAY: 1 ♂, Montevideo, on board R.Y.S. Valhalla, 15 Jan. '03 (*Nicoll*); BRAZIL: 1 ♀, Rio de Janeiro, at light, 7 Nov. '23 (*K. J. Hayward*); 1 ♀, Bahia, on board R.Y.S. Valhalla, 27 Dec. '02 (*Nicoll*); 1 ♂, Amazons.

The records made by Nicoll on board the R.Y.S. Valhalla are very doubtfully an index to distribution. It is probable that the ship herself was carrying the *E. cautella*, Wlk., to the places she was visiting.

Besides the localities given above, the following additional distribution is recorded in the literature:—Siberia (Ragonot, 1885); Germany (Zacher, 1926); Holland (Snellen, 1884); France (Ragonot, 1885); Switzerland (Vorbrodt and Müller-Rutz, 1914); Austria (Ragonot, 1885); Italy (De Stefani, 1919*b*); Crete (Rebel, 1916*a*); Malta (Andres, 1916); Smyrna (Smyth, 1911); Taurus Mts. (Ragonot and Hampson, 1901); Iraq (Ramachandra Rao, 1922); Senegal (Roubaud, 1917); Congo (Ragonot and Hampson, 1901); Mauritius (de Charmoy, 1915); Celebes (Snellen, 1884); Australia (Turner, 1904; Myers, 1928); U.S.A. (Chittenden, 1911); Costa Rica (Druce, 1890); Panama (Dyar, 1914); Trinidad (Chittenden, 1911); Venezuela (Chittenden, 1911).

In England it is found in towns as far north as Lancashire; there appear to be no records from Scotland or Ireland. According to Barrett (1905) it was first definitely recorded from England in 1873. *E. cautella* is especially a pest of dried fruits, to which it often does serious damage, *e.g.* to Smyrna figs. Cotton-seed and oil-cake made from it are also favourite foods. In warmer countries it can maintain itself out of doors, *e.g.* on figs at Smyrna (Smyth, 1911) or on dates in Egypt (Gough, 1914). The following foods have been recorded :—Cotton-seed cake (Atmore, 1884); cotton-seed (Morstatt, 1914); currants (Barrett, 1875); sultanas (Myers, 1928); raisins (Bioletti, 1915); dried apples (Chittenden, 1911); dates (Buxton, 1920; Gough, 1914); pomegranates (Gough, 1914); pears (Gough, 1914); citrus fruits, damaged and fallen (Hall, 1924); asparagus berries (Chittenden, 1911); seeds of *Zizyphus jubjuba* (Chittenden, 1911); chocolate (Barrett, 1905; Leefmans, 1925); cacao beans (Chittenden, 1897*a*; Hutson, 1921); tonka beans (Chittenden, 1911); *Cecropia palmata* seeds (Chittenden, 1911); gall-nuts, "gobaishi" (Chittenden, 1911); ground-nuts (Sheppard, 1926); locust beans (Buckler, 1882); chick pea (Chittenden, 1911); almonds (Sheppard, 1926); walnuts and pecans (Chittenden, 1911); rice (de Charmoy, 1915); biscuits (Andres, 1916; Durrant, 1921); wheat flour, bran, maize and maize meal, hominy and oatmeal (Chittenden, 1911).

Keuchenius' record (1915) of the larvae of *E. cautella* feeding on *Coccus viridis* and *Oregma* on coffee in Java must be received with caution. It may be due to misidentification, for certain allied genera are known to have Coccid-eating larvae (cf. *E. declivella*, Z.). Zehntner (1900, 24–6) also gives a substantial account of *E. cautella* feeding on the Aphid, *Ceratovacuna lanigera*, Zehnt., but the habits described do not appear to resemble those of an *Ephestia*.

Parasites and predators :—*Nemeritis canescens*, Gr., *Microbracon hebetor*, Say, *M. brevicornis*, Wesm., *Diachasma sicula*, De Stef., *Trichogramma minutum*, Riley, and *Pediculoides ventricosus*, Newp.

Richards and Herford (1930, p. 381, pl. 30, fig. 41) describe without naming an apparently distinct species of *Ephestia* allied to *E. cautella*. This form we now believe to be either pathological or else possibly a hybrid. The genitalia are often malformed or even apparently broken. The most likely parents, if it should prove to be a hybrid, would be *E. cautella* and *E. elutella*, but we have not so far induced these species to interbreed in the laboratory.

E. disputella, sp. n.

Forewings: drab-grey; elongate, costa gently curved throughout; 1st line broad, gently curved with its convexity outwards, inner margin scarcely paler; 2nd oblique towards the apex, nearly straight, white, inwardly margined with darker; 3rd faint; orbicular apparently absent, claviform distinct. Hindwings: whitish, narrowly margined with grey, cilia whitish with a darker subbasal line. M_{2+3} and Cu_{1a} approximated at base, enclosing a long fork. Exp. ♀ 18·5 mm.

Genitalia: ♀. (Pl. IX, fig. 72.) Ovipositor broad, bluntly rounded at apex, the struts shorter than the width of the 8th tergite, which is subquadrate, evenly chitinised; ductus bursae encircled by a dense patch of elongate, somewhat irregular, toothbearing chitinised spots in the neighbourhood of the bursa; bursa (Pl. IX, fig. 71) with no small chitinised spots; lamina dentata replaced by 5 chitinised plates, each of which has a small, hyaline area; ostium situated on the posterior margin of the 7th sternite (Pl. IX, fig. 73), under a punctate operculum (probably modified scales would arise in fresher specimens from the punctures); 7th tergite with a narrow chitinised strip on each side, from which probably modified scales arise.

Type: 1 ♀, INDIA: Dras, June '87, Leech Coll., in the British Museum Coll.

Subgenus **Strymax**, Dyar.

Strymax, Dyar (1914).
Ephestia, Hampson (1901) in part.
Unadilla, Hampson (1901) in part.

Type *S. dorae*, Dyar (1914, p. 344), by original designation.

Although described by Dyar as a genus, we regard this as merely a subgenus of *Ephestia*, distinguished mainly by the development of the chaetosema (Pl. V, fig. 13), which is covered with a rosette of white scales, instead of inconspicuous bristles, and by the male antennae, which are contracted just after the base. Some of the species are not yet known in both sexes, but the male genitalia, especially in the structure of the gnathos, appear to be distinctive.

E. (Strymax) albidiorella, sp. n.

Head and thorax whitish. Forewings: pale drab, suffused with white basally and on costal half, elongate, costa hardly curved; the dark dorsal half of the wing sends out a small projection in the direction of the costa at the position of the first line; 2nd white, outwardly margined with darker: 3rd scarcely indicated; stigmata small but distinct. Hindwings: white, narrowly margined with grey, cilia white. M_{2+3} and Cu_{1a} approximated at base, enclosing a long fork; Cu_{1b} approximate at base to Cu_{1a}. Exp. ♂ 17 mm.

♂. Forewing: dorsum above with no tuft of modified scales at base; base of costa narrowly deflected. When the costal fold is not expanded, no projecting scales can be seen. Hindwing: no areas of modified scales, neither pecten denser than in the female.

♂. 8th tergite almost entirely membranous, with a narrow anterior margin rather more chitinised.

Genitalia: ♂. (Pl. VII, fig. 34.) Saccus with its posterior margin bisinuate and with no definite membranous area; costa of valve with no tooth; ventral thickenings of the anellus consisting of a narrow transverse strip, at each end of which is articulated a narrow, longitudinally placed strip, pointed posteriorly; dorsal thickenings of the anellus absent, replaced by broad ventral thickenings of the tegumen itself; gnathos consisting of a triangular posterior area, with no lateral arms, and a large, subrectangular anterior lobe (about four times as long as the triangular area) scarcely emarginate anteriorly; subscaphium not transversely striate, consisting of two plates, each of which is strongly chitinised along a narrow strip at its anterior end; uncus broadly rounded; tegumen laterally produced into short, rounded lobes; aedeagus a very long subcylindrical tube, as long as the saccus and valves together, narrowing somewhat posteriorly; chitinised area (Pl. VII, fig. 35) of the vesica long and narrow, with a vermicular structure, especially at its anterior end.

Specimen seen: PERU: 1 ♂, Rio Ucayale, Contamino, Oct.–Dec., '12. Type in the British Museum. The name *albidiorella* was given by Hampson in manuscript.

E. (Strymax) bipunctella, Hampsn.

bipunctella. 1901: Hampson, 255 (*Ephestia*).
dorae. 1914: Dyar, 344 (*Strymax*).

Forewings: light drab, irrorated with white, elongate, costa nearly straight; 1st line rather before the middle, represented by two dark spots, inwardly margined with white; 2nd beyond the middle, rather strongly curved inwardly towards the dorsum, indistinct, white, narrowly margined inwardly and outwardly with darker; 3rd indicated; stigmata faint. Hindwings : whitish, narrowly margined with grey, cilia concolorous, with a darker subbasal line. M_{2+3} and Cu_{1a} approximated at base, enclosing a long fork; Cu_{1b} approximated at base to Cu_{1a}. Exp. ♂ 10–12·5, ♀ 10 mm.

♂. Forewing : Base of costa deflected, the fold, which is shorter than the frenulum, has no projecting scales; no tuft of modified scales near the base of the dorsum.

♂. 8th tergite almost entirely membranous, with a narrow anterior margin rather more chitinised; there are no tufts of modified scales. 8th sternite a narrow strip.

Genitalia : ♂. (Pl. VII, fig. 31.) Membranous area of saccus covering almost its entire width; costa of valve with no tooth, but distinctly incurved at its apex, tooth-like; ventral thickenings of the anellus produced on each side into an elongate, curved lobe, sharply pointed posteriorly; dorsal thickenings absent, replaced by broad ventral thickenings of the tegumen itself; gnathos in the form of a small isosceles triangle, with no lateral arms, anteriorly produced into a very large lobe (about 4 times as long as the triangular part of the gnathos), which is anteriorly deeply emarginate; subscaphium not transversely striate, but anteriorly with two small chitinised strips; uncus broadly rounded; tegumen laterally produced into short, rounded lobes; aedeagus a simple subcylindrical tube, with a patch of small chitinised spots on one side at the apex, chitinised area of the vesica hardly indicated.

♀. (Pl. XI, fig. 110.) Ovipositor nearly twice as long as broad, rather pointed, its struts about 5 times as long as the width of the 8th tergite, which is largely membranous, except for two lateral areas; ductus bursae entirely membranous; bursa (Pl. XI, fig. 111) with no small chitinised spots in its wall, the lamina dentata replaced by 14 narrow, serrate chitinised plates.

Specimens seen : PANAMA : 1 ♂, 1 ♀, La Chorrera, April, '12, Aug. (*Busck*), U.S. Nat. Mus.; BAHAMAS : 2 ♂♂, Nassau (*Bonhote*), one, 26 May '98, the other 11 May '98. The ♂ captured at Nassau on 26 May '98 is the type of *E. bipunctella*, Hampson. The Panama specimens are paratypes of *Strymax dorae*, Dyar, which is a synonym.

E. (Strymax) latercula, Hmpsn.

latercula. 1901 : Hampson, 255 (*Unadilla*).

Forewings : greyish, basal half reddish, elongate, costa hardly curved; specimens too worn to describe the markings. Hindwings : whitish, narrowly margined with grey, cilia whitish. M_{2+3} and Cu_{1a} approximated at base, enclosing a long fork. Exp. ♀ 16–17 mm.

Genitalia : ♀. (Pl. XI, fig. 109.) Ovipositor rounded, rather more than 1½ times as long as broad, its struts about 1½ times as long as the width of the 8th tergite, which is evenly chitinised, except for a small triangular membranous area in the centre of its anterior margin; the dorsal wall of the ostium bursae produced beyond the 7th sternite as a rounded lobe; ductus bursae strongly narrowed to the ostium, evenly chitinised posteriorly, membranous in the neighbourhood of the bursa; bursa (Pl. XI, fig. 108) with no small chitinised spots in its wall, lamina dentata consisting of 3 to 6 small triangular plates joined to form one or two irregular rows.

Specimens seen : BAHAMAS : 1 ♀, Nassau, 22 July '98 (*Bonhote*); COLOMBIA : 1 ♀, Mendez, 11 Dec. (*Petersen*), Zeller Coll. The Bahamas specimen is the type, while the Colombian one bears the label "*Euzophera latercula* Zeller m.s."

E. (Strymax) pyllis, Dyar.

pyllis. 1914 : Dyar, 344 (*Strymax*).

Forewings : pale drab-grey, irrorated with white, moderately elongate, costa nearly straight; 1st line slightly before the middle, oblique towards the base of the costa, strongly sinuate, dark, margined inwardly with whitish, and ending before the costa which at this point is broadly whitish; 2nd oblique towards the apex, very faint, whitish, narrowly margined with darker on both sides; 3rd indicated; stigmata present. Hindwings: whitish, narrowly margined with grey, cilia whitish, with a darker subbasal line. Cu_{1b} not approximated to Cu_{1a}, M_{2+3} and Cu_{1a} approximated at base, enclosing a long fork. Exp. ♀ 12 mm.

Genitalia: ♀. (Pl. XI, fig. 104.) Ovipositor considerably longer than broad, pointed, its struts about four times as long as the width of the 8th tergite, which is chitinised, except for a triangular posterior area and a narrow central strip which extends halfway towards the anterior margin; ductus bursae with a large area of small chitinised spots in the neighbourhood of the bursa; bursa (Pl. XI, fig. 105) with no small chitinised spots in its wall, the lamina dentata replaced by 12 chitinised plates.

Specimen seen: PANAMA: 1 ♀, Rio Trinidad, Mar. '12 (*A. Busck*), U.S. Nat. Mus. *E.* (*S.*) *pyllis* was described from Panama and the specimen described above is a paratype.

Plodia, Guenée.

Plodia, Guenée (1845*a*, p. 80), (1845*b*, p. 318).
Tinea, Hübner (1817, p. 45, fig. 310) in part, Fitch (1856).
Phycis, Duponchel (1836), (1842) in part.
Myelois, Zeller (1839*a*), (1847*a*) in part.
Ephestia, Zeller (1848*a* and *b*) in part, and many subsequent authors.
Monobasic, type *P.* [*Tinea*] *interpunctella* (Hübner, 1817), Guenée (1845).

This genus is closely allied to *Ephestia*, but differs essentially in the following particulars:—The labial palpi are directed forwards, not upwards; the head has a strong cone of scales, absent or weaker in *Ephestia*. The other characters are scarcely more than specific to *P. interpunctella* and may be paralleled in various species of *Ephestia*. Hering (1929, pp. 41–2) states that in the hindwings of *Plodia* M_2 is fully developed, while absent or only indicated in *Ephestia*; we have been unable to verify this character.

The following is a more complete diagnosis of the genus.

Face (Pl. V, fig. 12) with a cone of scales, directed forwards and downwards; antennae of the male shortly ciliated; galeae of the maxillae normally developed; maxillary palpi very short, filiform; in *P. interpunctella* with the scales removed, they are seen to be three-segmented, the first two segments subequal, about twice as long as broad, the third about as long as broad, rounded apically, the three together about the same length as the apical segment of the labial palpi; the labial palpi moderately long, porrect, clothed with appressed scales; when seen laterally the terminal segment is pointed and directed more downwards; in *P. interpunctella* with the scales removed, the basal segment is seen to be slightly thicker than the others, about 2½ times longer than broad, the second segment about twice as long as broad, slightly thickened towards the apex, the third segment shorter than the first, pointed apically, and distinctly shorter than the corresponding segment of the labial palpi of *Ephestia*. Spurs on the tibiae as in *Ephestia*, but the shorter apical spur of the hind tibiae in *P. interpunctella* often lies proximally to the large one; there is also a greater disparity in size between the spurs. Forewings (Pl. V, fig. 1*a*) as in *Ephestia*, but R_1 and R_2 continued to the costa; the base of the costa in the male deflected and enclosing modified scales; no tuft of modified scales at the base of the dorsum in the male. Hindwings (Pl. V, fig. 1*b*) as in *Ephestia*, but $Sc + R + M$ anastomosed to a little after the middle of the wing; $Sc + R$ arising near the apex of Rs; $R\text{–}M$ almost coincident with Rs, arising at the point of divergence of $Sc + R$, and visible only as a slight thickening of Rs; M_{2+3} and Cu_{1a} join at the point of divergence of $M\text{–}Cu$, which is obsolescent; veins Cu_1 and $1A + 2A$ each with a defined pecten of hairs, not much more developed in the male than in the female, that on the anal vein preceded by a small tuft of yellowish, spatulate scales of moderate length.

♂. Eighth tergite with 1–3 tufts of modified scales on each side.

Genitalia : ♂. The membranous area of the saccus covering more than half its width; costa of valve with a small tooth; ventral thickenings of the anellus consisting of single lobes on each side; dorsal thickenings of the anellus consisting of narrow longitudinal strips; gnathos posteriorly with no arms, but emitting a narrow, truncate, tongue-shaped process; tegumen laterally produced into short rounded lobes; aedeagus a simple subcylindrical tube; chitinised area of the vesica large, more than half as long as the aedeagus.

Ovipositor twice as long as broad, rounded at the apex, its struts twice as long as the width of the eighth tergite; dorsal wall of the ductus bursae of the ostium produced into a tongue-shaped process; bursa with no small chitinised spots, the lamina dentata consisting of a plate bearing 3–8 triangular teeth.

The nearest approach to this type of genitalia in *Ephestia* is seen in *E. kühniella*, Z., in the male and *E. rileyella*, Rag., and *E. declivella*, Z., in the female.

P. dolorosa, Dyar.

dolorosa. 1919 : Dyar, 63.

Described from Guatemala.

Labial palpi 2½ times as long as the eyes. Forewings : very near bistre, the veins somewhat sprinkled with black scales, elongate, costa moderately curved, more strongly towards the apex; 1st line absent; 2nd very near the termen, slightly darker than the ground-colour; 3rd very faint; stigmata absent. Hindwings moderately dark grey, narrowly margined with darker, cilia concolorous with a dark subbasal line. M_{2+3} and Cu_{1a} approximated at base, enclosing a long fork. Exp. ♂ 18 mm., ♀ 15 mm.

♂. Forewing : dorsum above with no tuft of modified scales near base; base of costa deflected, enclosing some long whitish scales at the base, a tuft of moderately long, pinkish white scales at the apex and between them a dense mass of short, pinkish-white, spatulate scales.

♂. Eighth tergite (Pl. VIII, fig. 45) largely membranous, with a chitinised central strip, expanding triangularly posteriorly, ending anteriorly in a very small, diamond-shaped process. On each side of the tergite anteriorly is a chitinised plate from which arise long modified scales not very sharply segregated into three tufts; of these the two inner ones are denser than the outer, and the scales of the centre tuft are sharply bent inwards at their apex; the tufts are of equal length.

Genitalia : ♂. Membranous area of the saccus covering a little more than half its width; costa of valve (Pl. VIII, fig. 62) with a small, blunt tooth at the centre of its dorsal margin; ventral thickenings of the anellus produced into broad, oval submembranous lobes on each side; only the narrow central part strongly chitinised; dorsal thickenings of the anellus forming narrow longitudinal strips; gnathos approximately square with a small, tongue-shaped posterior process, much more heavily chitinised; subscaphium and posterior half of the uncus missing in the single specimen examined; tegumen laterally produced into small rounded lobes; aedeagus a simple, subcylindrical tube with its apex very obliquely truncate; chitinised area of the vesica large, more than half as long as the aedeagus.

♀. Ovipositor twice as long as broad, rounded at the apex, its struts twice as long as the width of the eighth tergite, which is evenly chitinised almost throughout, only rather more heavily at the sides and anteriorly; the tergite anteriorly with a small, central emargination; ductus bursae evenly chitinised for the greater part of its length, membranous only in the neighbourhood of the bursa, the chitinised part produced into a small, tongue-shaped process at the ostium; the bursa (Pl. XI, fig. 114) with no small chitinised spots in the wall, the lamina dentata consisting of 3 small, triangular plates with their bases lying on a straight line.

Specimens seen : GUATEMALA : 1 ♂, Cayuga, coll. W. Schaus; 1 ♀, Cayuga, May, coll. Schaus and Barnes, U.S. Nat. Mus. These specimens are presumably paratypes and were kindly lent us by Mr. K. Heinrich of the U.S. National Museum.

P. interpunctella, Hb.

interpunctella. 1811–17 * : Hübner, pl. 45, fig. 310 (*Tinea*). 1836 : Duponchel, 224, pl. 280, fig. 5 (*Phycis*). 1839 : Zeller, *a*, 176 (*Myelois*). 1842 : Duponchel, 121, pl. 60, fig. 6 (*Phycis*). 1845 : Guenée, *a*, 80; *b*, 319 (*Plodia*). 1849 : Herrich-Schäffer, 110 (*Ephestia*). 1854 : Westwood, 274, pl. 56, fig. 1754. 1859 : Stainton, 169 (*Ephestia*). 1865 : von Heinemann, 202 (*Plodia*). 1872 : Morris, 116, pl. 80, fig. 4 (*Plodia*). 1880 : Frey, 280 (*Ephestia*). 1882 : Snellen, 163 (*Plodia*). 1885 : Ragonot, 25. 1886 : Leech, 98, pl. 11, fig. 11. 1890 : Hulst, 200. 1901 : Ragonot and Hampson, 305; Staudinger and Rebel, 15. 1902 : Dyar, 437. 1905 : Barrett, 62, pl. 431, figs. 3, 3*a*, 3*b*. 1910 : Spuler, 201, pl. 82, fig. 6. 1914 : Vorbrodt and Müller-Rutz, 309. 1915 : Parker, 283, fig. 1 and pl. 1. 1926 : Curran, 386, fig. 5. 1927 : Zacher, *b*, 246, figs. 1928 : Hill; Hudson, 156, pl. 45, fig. 7; Meyrick, 386; Myers, 8. 1930 : Richards and Herford, 380, pl. 27, pl., fig. 42 and pl. 31, fig. 46.

interpunctalis. 1816 : Hübner, 347 (*Euclita*) nomen nudum. 1879 : Butler, 273 (*Plodia*). 1896 : Druce, 286 (*Ephestia*).

zeae. 1856 : Fitch, 320, pl. 4, fig. 1 (*Tinea*). 1860 : Clemens, 206 (*Ephestia*).

elutella. 1898 : Froggatt, 1103, fig. (*Ephestia*). 1903 : Froggatt, 490 (*Ephestia*) *nec* Hübner 1796.

americana. 1920 : Piutti (*Plodia*) nomen nudum.

Ephestia roxburghii was doubtfully referred here by Hulst (1890, p. 200). For the synonymy of this name see under *E. elutella*, Hb.

Common names :—The Indian meal moth; Meal-worm moth; Cloaked knothorn; Compressed vegetable moth; Kupferrote Dörrobste Motte.

Labial palpi 1½ times as long as the eyes. Forewings : from base to 1st line whitish, thence to apex reddish-brown with leaden-grey suffusions, moderately elongate, costa nearly straight; 1st line a little before the middle, slightly sinuate, moderately oblique towards the base of the costa, leaden-grey; 2nd well beyond the middle, straight, parallel to the termen, leaden-grey; 3rd leaden-grey; stigmata absent, but a large triangular area between the 1st and 2nd lines is leaden-grey, enclosing a round, reddish-brown spot. Hindwings : whitish-grey, narrowly margined with darker, cilia whitish-grey with a darker subbasal line, veins somewhat dark-streaked. M_{2+3} and Cu_{1a} approximated at base, enclosing a long fork; Cu_{1b} not approximated to Cu_{1a}. Exp. ♂♀ 14–16 mm.

♂. Forewing : dorsum above with no tuft of modified scales at base; base of costa deflected, enclosing a dense tuft of moderately long, yellowish hair-scales. When the costal fold is not expanded some long whitish scales protrude at the base, and a large tuft of long, reddish-white scales at the apex. Hindwing : costal margin with an area of yellowish scales reaching to beyond the middle; no tuft of yellowish scales preceding the anal pecten, only the anal pecten dense, yellowish.

♂. 8th tergite (Pl. VIII, fig. 44) largely membranous, with a chitinised central strip which is triangularly expanded posteriorly, and bifurcates anteriorly; on each side of the tergite anteriorly a tuft of long modified scales arises from a small chitinised area.

Genitalia : ♂. (Pl. VII, fig. 32.) The membranous area of the saccus covering more than half its width; costa of valve (Pl. VIII, fig. 61) with a small tooth near its apex;

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* We accept the date given by Sherborn in his Index Animalium (Part II, p. 3224).

ventral thickenings of the anellus small, oval, pointed dorsally; dorsal thickenings of the anellus consisting of narrow longitudinal strips, fused across the mid-line posteriorly; gnathos approximately hexagonal, emitting a narrow, truncate, tongue-shaped process; subscaphium not transversely striate, 8 times longer than broad; uncus somewhat produced, truncate at apex; tegumen laterally produced into short, rounded lobes; aedeagus (Pl. VIII, fig. 60) a simple subcylindrical tube, chitinised area of vesica large, more than half as long as the aedeagus.

♀. (Pl. XI, fig. 112.) Ovipositor nearly twice as long as broad, rounded at the apex, its struts twice as long as the width of the eighth tergite, which is evenly chitinised and anteriorly broadly emarginate; ductus bursae very broad and rather strongly chitinised posteriorly; at the ostium the dorsal wall of the ductus is produced beyond the seventh sternite as a long tongue-shaped process, while the ventral wall is visible as two heavy chitinisations just posterior to the seventh sternite; bursa (Pl. XI, fig. 113) with no small chitinisations in its wall, the lamina dentata bearing 3–8 small teeth, whose bases are less chitinised.

Specimens seen: ENGLAND: numerous specimens in dried fruit warehouses, London (*O. W. R. and W. S. T.*); Gosport and Salisbury, Banks Coll., Exeter (*Stainton*); Ipswich (*Barrett*); Bournville (*Wadsworth*); HOLLAND: Breda, Zell. Coll.; SPAIN: Granada (*Wlsm.*); SOUTH AFRICA: Transvaal, Distant Coll.; CANARIES: S. Cruz (*Wlsm.*); MADEIRA: Machico (*Wlsm.*); ALGERIA: Dar al Beida (*Stainton*); Tangier and Hamman-es-Salahain (*Wlsm.*); EGYPT: Aswan (*K. J. Hayward*); CEYLON: Maskeliya; CHINA: Tientsin (*F. M. Thomson*); JAVA: Zell. Coll.; AUSTRALIA: S.E. Australia (*Rayner*); U.S.A.: Texas, Zell. Coll.; California, bred dried apricot, Oct. '98 (*S. H. Druce*); MEXICO: Ciudad, 8100 ft. (*Forrer*); near Durango City (*Becker*); Presidio (*Forrer*); BAHAMAS: Nassau (*Bonhote*); GRAND CAYMAN: (*Wlsm.*); BRAZIL: Bahia (*Meade-Waldo*); ARGENTINE: Villa Anna, F.C.S.F. (*K. J. Hayward*); CHILE: 1 specimen, no further data; PERU: Callao (*Walker*).

P. interpunctella has been recorded from the following countries besides those from which we have seen specimens:—Belgium (Crombrugghe de Picquendaele, 1906); France (Bruand, 1847, etc.); Germany (Sorhagen, 1882, etc.); Esthonia (Sintenis, 1881); Latvia (Teich, 1889); Russia (Vitkovsky, 1915, etc.); Bulgaria (Rebel, 1903); Fiume (Abafi-Aigner, 1896); Hungary (Abafi-Aigner, 1896); Austria (Andres, 1919, etc.); Switzerland (Frey, 1880); Italy (Camerano, 1883, etc.); Sardinia and Corsica (Duponchel, 1836, 1842); Crete (Rebel, 1916*a*); Malta (Andres, 1916); Turkey (Mann, 1862; Staudinger, 1879); Japan (Kuwara, 1919); W. Africa (Azemard, 1914); Hawaii (Butler, 1879); New Zealand (Hudson, 1928); Canada (Fletcher, 1889*b*, etc.); Virgin Isles (Wilson, 1921); St. Thomas (Zeller, 1876); Chile (Ragonot and Hampson, 1901).

In England the moth was first noted in London in 1847 (Barrett, 1905) and has since been found over a greater part of the country. It does not appear to be recorded from Scotland, but in Ireland has been found at Belfast (Barrett, 1905). In this country it is rare except in warehouses in large towns. *P. interpunctella* is one of the few species whose range is literally cosmopolitan.

The larva of *Plodia* is able to feed on an even wider range of foods than the larvae of *Ephestia*. Dried fruits, nuts and maize are probably the most important foods but the following have been recorded:—Dried peaches (Chittenden, 1902); dried grapes (Berce, 1878; Lyon, 1924); dried apricots (Chittenden, 1902; Richards and Herford, 1930); pineapples (Barrett, 1905); raisins (Chittenden, 1902; Bioletti, 1915); dried pears (Richards and Herford, 1930); dried apple slices (Rössler, 1880); apples on the ground and on the tree (Treherne, 1921); plums (Chittenden, 1902); prunes (Berce, 1878; Chittenden, 1902); currants (Howard, 1895*b*; Snellen, 1882); dried bananas (Zacher, 1930); figs (Andres, 1919; Hagan, 1929); chickasaw plums (Riley, 1889); dates (Stickney, 1924); dried loganberries (Lovett, 1921); dried cherries (Zvierezomb, 1919); bilberries (Sorhagen, 1882); fruit of *Zizyphus spinachristi* (Andres, 1919); candied fruit (Abafi-Aigner, 1899); lozenges (Anon., 1883); drugs—*Juniperus communis, Cydonia vulgaris, Rosa canina, Datura stramonium* (van Emden, 1924) and *Secale cornutum, Cannabis sativa, Prunus spinosa, Sarothamnus scoparius, Archangelica officinalis, Verbascum thapsiforme, Tussilago farfara, Sambucus nigra* (van Emden, 1925*a*); jellies (Hulst, 1890); preserves (Clemens, 1860); marzipan (Zacher, 1927*a*); nougat (Fallou and Ragonot, 1871); chocolate-covered candies (Lovett, 1921); chocolate-covered almonds (Dattin, 1927); cacao (Chittenden, 1902); ground-nuts (Popenoe, 1911; Azémard, 1914); pecans (Riley, 1889); almonds, especially shelled (Berce, 1878; Barrett, 1905; Anon., 1924); walnuts, especially shelled (Theobald, 1896; Barrett, 1905; Müller-Rutz, 1927); locust beans (Barrett, 1905; Bridwell, 1920*b*); chestnuts, cooked and raw (Fallou and Ragonot, 1871); beans (Chittenden, 1902); peas (Girault, 1912); chickpeas (Chittenden, 1902); acorns (Chittenden, 1902); seeds of *Pinus pinea* (Duponchel, 1836); seeds of spruce (Sorhagen, 1882); caraway seeds (Barrett, 1905); clover seed (Clemens, 1860); palm seed (Strong, 1921); seeds of salamander lettuce (Riley, 1889); garlic heads (Clemens, 1860); sliced beet (Andres, 1919); compressed vegetables (Froggatt, 1903); chillies (Strong, 1922); lupins (De Stefani, 1919*b*; Anon., 1920); herbarium specimens (Chittenden, 1902); dandelion root (Riley, 1889); dried Opuntia (Riley, 1889); cinnamon bark (Riley, 1889); yeast cakes (Barrett, 1905); rye (Clemens, 1860); rice (said to husk the rice to make it white, Kazui, 1919); wheat (MacCarthy, 1922); maize (Clemens, 1860; Riley, 1889; Barrett, 1905; Durrant, 1921); maize meal (Fitch, 1856; Andres, 1919); malt (Barrett, 1905); cakes (Bruand, 1847); honey cakes (Dampf, 1908); bread (Berce, 1878; Fallou and Ragonot, 1871); biscuit (Berce, 1878; Curo, 1880; Camerano, 1883); macaroni (Bruand, 1847); breakfast cereals (Gibson, 1917); flour (Chittenden, 1902); in flour mills (Fletcher, 1890*b*; Andres, 1919); old books (Riley, 1889); fur (Sorhagen, 1882); dead insects (Curo, 1880; Barrett, 1905); in beehives (Fletcher, 1889*a*); in humble-bee nests, especially in captivity (Frison, 1926); on stored frames from beehives (Dunham, 1929).

There are extremely few records of *Plodia* maintaining itself out of doors. Treherne (1921) states that in British Columbia the larva is found under the burlap bands on apple trees in codling moth quarantine areas, and commonly on dried apples left as refuse in the orchard or packing shed. More rarely the larva feeds on apples actually on the tree. In Europe the adult is only rarely found outside houses and warehouses, the larva probably never. Even in the warm Australian climate, the moth does not occur in the vineyards or drying sheds, and infestation of dried fruit does not begin until the packing sheds are reached (Myers, 1928).

The following parasites and predators of *P. interpunctella* have been recorded :—*Nemeritis canescens*, Grav., *Limneria ephestiae*, Ashmd. (?), *Microbracon hebetor*, Say, *Dibrachys cavus*, Wlk., *Holepyris hawaiiensis*, Ashmd. (in artificial conditions), *Iridomyrmex detectus*, Sm., *I. rufoniger*, Lowne, *Piezostethus flavipes*, Reut. (?).

ALPHABETICAL LIST OF THE SPECIES AND THEIR SYNONYMS.

Species which are redescribed in the present paper are followed by a page reference. Species which we have not examined are followed by a reference to the original description and typical locality. New species or new synonymy are preceded by an asterisk.

abnormalella, Ragonot (1887*a*, 256). Ferghana.
abstersella, Z. (p. 177).
afflatella, Mn. (p. 193).
**albidiorella*, sp. n. (*Strymax*) (p. 201).
**amarella*, Dyar, see *E. elutella*, Hb.
**americana*, Piutti (nomen nudum), see *Plodia interpunctella*, Hb.
animosella, Dyar, see *E. declivella*, Z.
bacilella, Ragonot (1887*a*, 257). Taurus Mts. (cf. *minorella*, von Caradja).
baptella, Ragonot (1887*a*, 257). Samarkand.
**bengasiella*, Trti., see *E. calidella*, Gn.
bipunctella, Hmpsn. (*Strymax*) (p. 201).
bizonella, Ragonot (1888, 36). Sarepta (cf. p. 187).
cahiritella, Z., see *E. cautella*, Wlk.
calidella, Gn. (p. 196).
calonella, Rag. (p. 175).
cautella, Wlk. (p. 197).
clothella, Mill., see *E. afflatella*, Mn.
coarctella, Ragonot (1887*a*, 257). Amasia.
colorella, Dyar (p. 192).
constrictella, von Caradja (1929, 59). Rumania.
declivella, Z. (p. 175).
desuetella, Wlk., see *E. cautella*, Wlk.
desuetella, Meyrick, see *E. figulilella*, Gregs.
disparella, Rag. (p. 189).
**disputella*, sp. n. (p. 200).
divergens, Dyar (1914, 345). Panama.
dolorosa, Dyar (*Plodia*) (p. 204).
**dorae*, Dyar, see *E. bipunctella*, Hmpsn. (*Strymax*) (p. 201).
**dowsoniella*, sp. n. (p. 182).
elutella, Hb. (p. 185).
**ernestinella*, Trti., see *E. figulilella*, Gregs.
ficella, Dougl., see *E. calidella*, Gn.
ficulella, Barr., see *E. figulilella*, Gregs.
figulilella, Gregs. (p. 194).
furcatella, Herrich-Schäffer (1849, 107, pl. 12, fig. 82). Austria.
**fuscofasciella*, Rag., see *E. kühniella*, Z.
gemina, Haw., see *E. elutella*, Hb.
gitonella, Druce, see *E. kühniella*, Z.
gnidiella, Nolcken (*nec* Millière), see *E. calidella*, Gn.
gypsella, Ragonot (1887*a*, 256). N.W. Persia and Transcaspia.
habenella, Ragonot (1887*a*, 257). Sicily.
homoesomella, Zerny (1926, 22). Corsica.
icosiella, Ragonot (1888, 36). Algeria.
immodestella, Rebel (1916*b*, 41). Syria (cf. *modestella*, Rag.).
inductella, Staudinger (1879, 229). Asia Minor.

infumatella, Ragonot (1887*a*, 257). Spain.
interfusella, Ragonot and Hampson (1901, 290, pl. 34, fig. 17). Asia Minor.
interpunctalis, Druce, see *Plodia interpunctella*, Hb.
interpunctella, Hb. (*Plodia*) (p. 205).
irroratella, Ragonot (1887*a*, 256). Spain.
kühniella, Z. (p. 177).
**latercula*, Hmpsn. (*Strymax*) (p. 202). [From *Unadilla.*]
leonhardi, Rebel (1910, 426). Cephalonia.
majorella, Dyar (1922, 173). Mexico.
mediterranella, Mill., see *E. tephrinella*, Led.
metoenella, Zerny, see *E. mistralella*, Mill.
micaceella, Rag. (p. 183).
milleri, Z., see *E. figulilella*, Gregs.
minorella, von Caradja (1910, 120, pl. 1, fig. 4). Biskra. (A variety of *E. bacilella*, Rag.)
mistralella, Mill. (p. 184).
modestella, Ragonot in part (*nec* Lederer), see *E. immodestella*, Reb.
moebiusi, Rebel (p. 184).
neuricella, Zeller (1848*b*, 862). Country of origin uncertain.
nonparilella, Dyar (1904*a*, 113). Arizona.
parasitella, Stdgr. (p. 190).
**parasitella*, Kirby, see *E. elutella*, Hb.
passulella, Barr., see *E. cautella*, Wlk.
patriciella, Dyar (1918, 140). Cuba.
philetella, Rebel (1916*a*, 145). Crete.
philomenella, Mill., see *E. afflatella*, Mn.
pyllis, Dyar (*Strymax*) (p. 202).
ragonotella, Millière (1881, 4, pl. 10, fig. 6). France (cf. *uniformella*, Viard).
rectifasciella, Trti., see *E. disparella*, Rag.
rectivittella, Ragonot and Hampson (1901, 293, pl. 42, fig. 19). Madagascar.
**reductella*, Mn., see *E. afflatella*, Mn.
rhenanella, Fuchs, see *E. tephrinella*, Led.
rileyella, Rag. (p. 182).
roxburghii, Gregs., see *E. elutella*, Hb.
**roxburgi*, Trti., see *E. vapidella*, Mn.
roxburgii, Stdgr. and Reb., see *E. elutella*, Hb.
rubrimediella, Hmpsn. (p. 176).
rufa, Haw., see *E. elutella*, Hb.
**scipionella*, Turati (1924, 133, pl. 5, fig. 20). Type examined. Not an *Ephestia*, but the generic position could not be fixed. Possibly a new genus.
scotella, Hmpsn. (p. 174).
semirufa, Haw., see *E. elutella*, Hb.
**semirufa*, Stainton and some English authors, see *E. woodiella*, sp. n.
**semirufella*, Morris, see *E. woodiella*, sp. n.
sericaria, Scott, see *E. kühniella*, Z.
stenopterella, Turati (1929, 115, fig. 1). Tripoli.
suffusella, Ragonot and Hampson (1901, 304, pl. 49, fig. 18). Algeria.
tephrinella, Led. (p. 181).
unicolorella, Stdgr., see *E. elutella*, Hb.
uniformella, Viard (1915). France. A variety of *E. ragonotella*, Mill.
vapidella, Mn. (p. 174).

**venosella*, Trti., see *E. figulilella*, Gregs.
vitivora, Filipjev (1931, 70, figs.). Transcaucasia.
welseriella, Z. (p. 181).
**woodiella*, sp. n. (p. 191).
xanthotricha, Stdgr., see *E. calidella*, Gn.
zeae, Fitch, see *Plodia interpunctella*, Hb.
zosteriella, Ragonot (1887*a*, 257). Asia Minor (cf. *E. elutella*, Hb.).

A KEY TO THE SPECIES OF *EPHESTIA* AND *PLODIA* EXAMINED.

1. Labial palpi directed forwards. (Head with a cone of scales; chaetosema inconspicuous; forewings of the male with a basal costal fold; M_{2+3} and Cu_{1a} approximated at the base, enclosing a long fork.) *Plodia*, Gn. 2.

— Labial palpi directed upwards. (Head without a cone of scales, or, *E. rileyella*, Rag., and *E. declivella*, Z., with a rather obtuse one.) . . 3.

2. Forewings with the basal third conspicuously pale. Labial palpi less than one and a half times as long as the eyes. ♂. Eighth tergite with one tuft of modified scales on each side anteriorly. Tooth of the costa of the valve almost at the apex. ♀. Eighth tergite evenly chitinised throughout, with an anterior emargination; ductus bursae evenly chitinised, somewhat longer than broad; lamina dentata consisting of 3–8 small teeth emitted by a narrow, curved, chitinised strip. *P. interpunctella*, Hb.

— Forewings concolorous. Labial palpi fully two and a half times as long as the eyes. ♂. Eighth tergite with three tufts of modified scales on each side anteriorly. Tooth of the costa of the valve halfway between the base and apex. ♀. Eighth tergite almost evenly chitinised throughout; ductus bursae evenly chitinised, much longer than broad, with a tongue-shaped process at the ostium; lamina dentata consisting of three triangular plates only touching each other at one corner. *P. dolorosa*, Dyar.

3. Chaetosema forming a conspicuous rosette of white scales. (Male antennae contracted just after the base; the basal costal fold of the forewings small or absent; dorsal thickenings of the anellus not developed.) Subgenus *Strymax*, Dyar . . . . 4.

— Chaetosema inconspicuous, with whitish bristles. *Ephestia*, Gn. . . . 7.

4. Cu_{1b} in the hindwings closely approximated to Cu_{1a}. *Strymax* s.s. . . 5.

— Cu_{1b} in the hindwings arises from a point far removed from the base of Cu_{1a}. (Males not seen by us.) Group of *E.* (*S.*) *latercula*, Z. . . . . . . 6.

5. Costa of the valve in the male not produced into a tooth. Ventral thickenings of the anellus consisting of a simple lobe on each side. Gnathos not emarginate anteriorly. Aedeagus simple at its apex. Chitinised area of the vesica with a vermiculate structure. *E.* (*S.*) *albidiorella*, sp. n. ♂.

— Costa of valve incurved at its apex, forming a small tooth. Ventral thickenings of the anellus consisting of strongly curved, pointed lobes on each side. Gnathos emarginate anteriorly. Aedeagus with a patch of small chitinised spots on one side of its apex. Chitinised area of the vesica hardly developed. (The female with the eighth tergite membranous except for two lateral areas. Ductus bursae entirely membranous. Lamina dentata replaced by fourteen narrow, serrate chitinised plates.) . . . . *E.* (*S.*) *bipunctella*, Hmpsn.

6. Eighth tergite in the female evenly chitinised except for a small, triangular membranous area in the centre of its anterior margin. The ostium bursae produced beyond the seventh sternite as a rounded lobe. Ductus bursae strongly chitinised in the neighbourhood of the ostium, membranous towards the bursa. Lamina dentata consisting of three to six small, triangular plates joined to form one or two irregular rows *E.* (*S.*) *latercula*, Hmpsn.

— Eighth tergite evenly chitinised except for a triangular posterior area and a narrow central strip which extends halfway towards the anterior margin. Ostium bursae simple. Ductus bursae membranous except for a number of chitinised spots in the neighbourhood of the bursa. Lamina dentata replaced by twelve chitinised plates . *E.* (*S.*) *pyllis*, Dyar.

7. M_{2+3} and Cu_{1a} (in hindwings) with a long stalk, not much shorter than the fork they enclose. (In the female the lamina dentata of the bursa consists of a single tooth-bearing plate; males not seen by us.) Group of *E. vapidella*, Mn. . . . . 8.

— M_{2+3} and Cu_{1a} unstalked or with a stalk many times shorter than the length of the fork . . . . 9.

8. Eighth tergite in the female with a long anterior emargination, whose edge is heavily chitinised, the chitinisation extending backwards as a central strip almost to the posterior margin. Ductus bursae near the bursa with a long, broad section covered with dense, moderately large, chitinised spots. Lamina dentata with four to five rows of teeth. *E. vapidella*, Mn.

— Eighth tergite largely membranous, with the sides and a narrow anterior margin, emitting a broad, bilobed central process, more chitinised. Ductus bursae near the bursa with a patch of minute chitinised spots. Lamina dentata with one to two rows of teeth . . . *E. scotella*, Hmpsn.

9. Males . . . . 10.

— Females . . . . 25.

10. Forewings without a basal costal fold. (Hindwings with no tufts of modified scales; M_{2+3} and Cu_{1a} approximated at their base, enclosing a long fork.) . . . . 11.

— Forewings with a basal costal fold. (Eighth tergite with tufts of modified scales.) . . . . 14.

11. Antennae with the first segment thickened and excised at the apex above. The eighth tergite unmodified, without scale tufts. Membranous area of the saccus covering about three-quarters of its width. Struts supporting the gnathos directed transversely or even somewhat anteriorly. Ventral thickenings of the anellus in the form of small crescentic lobes. Aedeagus very elongate, with a small apical tooth. Vesica with two thickenings, each bearing two or three teeth. (Costa of the valve produced into a long, apical tooth. Dorsal thickenings of the anellus absent. Subscaphium five and half times as long as broad.) . . . . *E. rubrimediella*, Hmpsn.

— Antennae simple. Eighth tergite modified, with 1–3 scale tufts on each side. Membranous area of the saccus covering about half its width. Struts supporting the gnathos directed posteriorly. Ventral thickenings of the anellus bilobed, the posterior lobe small and acutely pointed. Aedeagus shorter, with no tooth. The vesica with only one large, untoothed thickening . . . . 12.

12. Eighth tergite with three tufts of modified scales on each side. Dorsal thickenings of the anellus fused across the mid line, their apices separated by a U-shaped emargination. Subscaphium about as long as broad. (Costa of the valve with a short, broad subapical tooth. Gnathos with two posterior arms.) . . . . *E. abstersella*, Z.

— Eighth tergite with one tuft of modified scales on each side. Dorsal thickenings of the anellus in the form of elongate, parallel-sided strips, not fused across the mid line. Subscaphium two and a half to four times longer than broad. . . . . 13.

13. Central strip of the eighth tergite ending in two diverging arms. Costa of the valve produced into an apical tooth. Gnathos with no posterior arms. Subscaphium about four times as long as broad. Aedeagus widened at the apex. Chitinisation of the vesica narrow, bar-like, about as long as the width of the aedeagus. . . . . *E. kühniella*, Z.

Central strip of the eighth tergite ending in a transverse bar. Costa of the valve not produced into an apical tooth. Gnathos with long posterior arms. Subscaphium about two and a half times as long as broad. Aedeagus subcylindrical. Chitinisation of the vesica ill-defined, about half as long as the aedeagus . . . . *E. welseriella*, Z.

14. Hindwings with neither the anal nor cubital pecten dense and yellowish. (Hindwings with M_{2+3} and Cu_{1a} shortly stalked, enclosing a short fork. Costa of valve not produced into a tooth.) . . . . 15.

— Hindwings with at least the anal pecten dense and in nearly every case yellowish . . . . 17.

15. Eighth tergite with a central chitinised strip, which is trilobed posteriorly and expanded into a large triangular area anteriorly. Three tufts of modified scales of equal size on each side. Dorsal thickenings of the anellus bent outwards into a hook posteriorly. Gnathos much broader than long, with two short posterior arms. Subscaphium at least twice as long as broad. . . . . *E. moebiusi*, Rebel.

— Eighth tergite with a central chitinised strip expanded into a small triangular area at each end. Three or four tufts of modified scales, of which one is much larger than the others, on each side. Dorsal thickenings of the anellus not bent outwards posteriorly. Gnathos longer than broad, with no posterior arms. Subscaphium a little longer than broad 16.

16. Head with an obtuse cone of scales. Forewings white with the base of the costa black and the lines represented by a series of black dots. The membranous area of the saccus covering about half its width. One of the lobes of the ventral thickenings of the anellus narrow and parallel-sided, joined posteriorly by a transverse bar. Gnathos pentagonal with the angles rounded . . . . *E. rileyella*, Rag.

— Head with no cone of scales. Forewings light drab, the lines continuous. The membranous area of the saccus covering about three-quarters of its width. The ventral thickenings of the anellus bilobed, the lobes small, rounded, of equal size. Dorsal thickenings apparently absent. *E. micaceella*, Rag. (?).

17. Hindwings with both the anal and cubital pecten dense, and nearly always yellowish. M_{2+3} and Cu_{1a} stalked and enclosing a short fork. (The tufts of the eighth tergite consisting of four groups of modified scales on each side all directed posteriorly; one group is not more than one-quarter the length of the others. Dorsal thickenings of the anellus usually curved outwards posteriorly, not developed into two complex lobes.) Group of *E. elutella*, Hb. 18.

— Hindwings with only the anal pecten dense and yellowish. M_{2+3} and Cu_{1a} approximated at the base, very rarely shortly stalked, enclosing a long fork . . . . 21.

18. Costa of the valve not produced into a subapical tooth. The outwardly directed hooks at the posterior ends of the dorsal thickenings of the anellus large . . . . *E. elutella*, Hb.

— Costa of valve produced into a small subapical tooth. The outwardly directed hooks at the apex of the dorsal thickenings of the anellus much smaller and narrower . . . . 19.

19. Scale-tufts of the hindwings whitish, the cubital one not very dense. Apex of the dorsal thickenings of the anellus scarcely at all curved outwards. The gnathos with very long posterior arms . . . . *E. disparella*, Rag.

— Scale-tufts of the hindwings yellow, the cubital one dense. Apex of the dorsal thickenings of the anellus distinctly curved outwards. Gnathos with short posterior arms as in *E. elutella* . . . . 20.

20. Apex of the dorsal thickenings of the anellus parallel-sided. The gnathos narrowly truncated posteriorly . . . . *E. parasitella*, Stdgr.

— Apex of the dorsal thickenings of the anellus expanded. The gnathos pointed anteriorly . . . . *E. woodiella*, sp. n.

21. Eighth tergite with four tufts of modified scales on each side; three of the tufts arise from two transverse chitinised plates and the fourth from a plate placed almost longitudinally; the tufts are all of about the same length, but the outermost one is much broader than the others. Costa of the valve without a tooth. Gnathos not present as a single structure, but each strut bears a large, posteriorly directed process, whose apex is bent inwards into a sharp hook. (Subscaphium not transversely striate. Chitinisation of the vesica two-fifths as long as the aedeagus and five times as long as broad.) . . . . *E. colorella*, Dyar.

— Eighth tergite with four tufts of modified scales on each side, directed posteriorly, the shortest not less than half as long as the longest; further a large transverse group of modified scales, which, when the tufts are expanded, are directed anteriorly. Costa of the valve with a tooth. Gnathos normally developed, the central part scarcely wider than the posterior arms are long. Dorsal thickenings of the anellus developed into more or less complex lobes posteriorly. The chitinisation in the vesica not much longer than the breadth of the aedeagus
Group of *E. cautella*, Wlk.

22. Ventral thickenings of the anellus bilobed; the dorsal thickenings very broad, only very indistinctly bilobed posteriorly. Posterior arms of the gnathos shorter than the central part. (Subscaphium scarcely transversely striate. Tegumen laterally produced into a long, finger-shaped process, somewhat incurved at the apex. Costal fold of the forewings enclosing a twisted agglomeration of scales; in the unexpanded condition the apical tuft is not very long.) . . . . *E. afflatella*, Mn.

— Ventral thickenings of the anellus not bilobed; the dorsal thickenings less broad, distinctly bilobed posteriorly. Posterior arms of the gnathos as long or longer than the central part. . . . . 23.

23. The apical tuft of the costal fold of the forewings very long. Tooth of the costa very long, parallel-sided almost to its base. Dorsal thickenings of the anellus narrow, parallel-sided, with two narrow posterior lobes, of which the lateral one ends in a small rounded knob. Tegumen laterally produced into a broad rounded lobe. (The subscaphium not transversely striate. Costal fold of the forewings enclosing a twisted agglomeration of scales.) . . . . *E. figulilella*, Gregs.

— Apical tuft of the costal fold not very long. Tooth of the valve not so long, widening towards its base. Dorsal thickenings of the anellus broader, composed of four irregular lobes. Tegumen laterally produced into a long, finger-shaped process . . . . 24.

24. Costal fold enclosing a twisted agglomeration of scales. Dorsal thickenings of the anellus produced posteriorly into a nearly semicircular lateral lobe and a median one which fuses on the median line with its fellow from the other side. Subscaphium much broader than long, strongly transversely striate . . . . *E. calidella*, Gn.

— Costal fold not enclosing a twisted agglomeration of scales. Dorsal thickenings of the anellus produced posteriorly into a nearly circular lateral lobe and a much narrower median one which does not meet its fellow from the other side. Subscaphium about as long as broad, not transversely striate . . . . *E. cautella*, Wlk.

25. Ovipositor reflected under the eighth sternite. (Hindwings with M_{2+3} and Cu_{1a} very shortly stalked, enclosing a moderately long fork. Eighth tergite evenly chitinised. A crescentic chitinised area in the membrane between the seventh and eighth sternites. Ductus bursae expanded and longitudinally folded near the ostium bursae, evenly chitinised throughout. Lamina dentata with two rows of five long teeth.) *E. colorella*, Dyar.

— Ovipositor not reflected under the eighth sternite . . . . 26.

26. Lamina dentata consisting of a toothed plate. (M_{2+3} and Cu_{1a} enclosing a moderately long fork. Ovipositor at least twice as long as broad.) . . 27.

— Lamina dentata consisting of 1–18 simple plates or of 43–60 conical chitinised spots . . . . 28.

27. Head with an obtuse cone of scales. Eighth tergite with a transverse central area less chitinised than either the posterior or anterior part. Ovipositor-struts not more than twice as long as the width of the eighth tergite. Ostium bursae produced beyond the seventh sternite into a large lobe. Ductus bursae longitudinally folded near the ostium, evenly chitinised for nearly all its length . . . . . . *E. declivella*, Z.

— Eighth tergite evenly chitinised except for a membranous, V-shaped, posterior area. Ovipositor struts at least five times as long as the width of the eighth tergite. (Hindwings uniformly dark.) . *E. calonella* Rag.(?).

28. Ovipositor struts about four times as long as the width of the eighth tergite. (M_{2+3} and Cu_{1a} enclosing a long fork.) . . . . 29.

— Ovipositor struts not more than two and a half times as long as the width of the eighth tergite . . . . 31.

29. Eighth tergite evenly chitinised except for a membranous, V-shaped, posterior area. Ductus bursae evenly chitinised, separate chitinised spots being visible only in the immediate neighbourhood of the bursa. Lamina dentata absent . . . . *E. rubrimediella*, Hmpsn.

— Eighth tergite chitinised throughout, with the anterior edge emarginate. Ductus bursae membranous with a large patch of chitinised spots in the neighbourhood of the bursa. Lamina dentata replaced by 1–6 chitinised plates . . . . 30.

30. Eighth tergite about two and a half times as long as broad, the anterior emargination narrow. Lamina dentata replaced by 1–4 plates *E. kühniella*, Z.

— Eighth tergite scarcely twice as long as broad, the anterior emargination including the greater part of the width of the tergite. Lamina dentata replaced by 6 plates. (Seventh sternite with two rectangular more chitinised areas.) . . . . *E. tephrinella*, Led.

31. Head with an obtuse cone of scales. Ductus bursae posteriorly evenly chitinised, somewhat expanded and thrown into longitudinal folds at the ostium. Bursa with a patch of small chitinised spots. The lamina dentata consisting of a single triangular plate. (Hindwings with M_{2+3} and Cu_{1a} shortly stalked, enclosing a short fork. Eighth tergite evenly chitinised, except for a small V-shaped, membranous area posteriorly.) *E. rileyella*, Rag.

— Ductus bursae not evenly chitinised, nor expanded and thrown into longitudinal folds. Lamina dentata replaced by at least two plates. . . . 32.

32. Eighth tergite moderately strongly chitinised throughout, especially over a tongue-shaped median area and a narrow anterior strip. Ductus bursae entirely membranous. The walls of the elongate bursa with forty-three conical chitinisations. (Hindwings with M_{2+3} and Cu_{1a} enclosing a long fork. Ovipositor rather longer than broad.) . . . . *E. welseriella*, Z.

— Species resembling *E. welseriella*, but eighth tergite evenly chitinised and the walls of the bursa with over sixty chitinisations . . *E. dowsoniella*, sp. n.

— Eighth tergite quite differently chitinised. Ductus bursae with either chitinised spots or plates. The walls of the bursa with two or more chitinised plates . . . . 33.

33. Hindwings with M_{2+3} and Cu_{1a} shortly stalked enclosing a short fork. Apical half of the ovipositor narrow, not more than a quarter as wide as its length. Ductus bursae with a number of small irregularly arranged chitinised spots in the region of the bursa. Group of *E. elutella*, Hb . . 34.

— Hindwings with M_{2+3} and Cu_{1a} approximated at their base, enclosing a long fork. Ovipositor obtusely rounded, as broad as long or broader. Ductus bursae with either a long, chitinised plate or a series of regularly arranged chitinised spots. Group of *E. cautella*, Wlk. . . . . . . 37.

34. Seventh sternite with two isolated, rectangular, more chitinised areas. (Anterior chitinised area of the eighth tergite produced backwards into a rounded projection, intermediate in shape between those of *E. elutella*, Hb., and *E. woodiella*, sp. n.) . . . . *E. parasitella*, Stdgr.

— Seventh sternite evenly chitinised . . . . 35.

35. Eighteen plates in the walls of the bursa (in the single specimen seen), many of the large ones being replaced by two small ones. (Eighth tergite as in *E. parasitella*, Stdgr.) . . . . *E. moebiusi*, Rebel.

— Six to seventeen plates in the walls of the bursa . . . . 36.

36. Anterior chitinised area of the eighth tergite produced backwards into a narrow, pointed projection. Six to ten, usually seven to eight, chitinised plates in the walls of the bursa . . . . . *E. elutella*, Hb.

— Anterior chitinised area of the eighth tergite produced backwards into a broad, rounded projection. Nine to seventeen, usually twelve, plates in the walls of the bursa. Ductus bursae with fewer and smaller chitinised spots . . . . *E. woodiella*, sp. n.

37. Eighth tergite largely membranous with the sides and a narrow anterior strip more chitinised. Ductus bursae with an elongate striate plate. (Bursa in the neighbourhood of the ductus with numerous small, chitinised spots.) No fan of modified scales arising from chitinised strips in the membrane between the seventh and eighth sternites . . . . 38.

— Eighth tergite evenly chitinised throughout. Ductus bursae with a spirally arranged series of chitinised spots. A fan of modified scales arises from a chitinised strip on each side in the membrane between the seventh and eighth sternite (or, *E. disputella*, sp. n., in the seventh sternite) . . . 39.

38. Seventh sternite reflexed beneath the ostium bursae. The plate in the ductus bursae becomes wider in the direction of the bursa. Lamina dentata replaced by 4–11, usually 6–8, chitinised plates. . *E. calidella*, Gn.

— Seventh sternite not reflexed. The plate in the ductus bursae nearly parallel sided. Lamina dentata replaced by 1–5, usually 2–3, chitinised plates *E. cautella*, Wlk.

39. Chitinised spots in the wall of the ductus bursae arranged in two single rows. Bursa with a large patch of very closely set, chitinised teeth at its anterior end. Lamina dentata replaced by 4–7, spindle-shaped chitinised plates . . . . *E. figulilella*, Gregs.

— Chitinised spots in the walls of the ductus bursae arranged in a broad band. Bursa without a patch of chitinised spots at its anterior end, but with 3–7 elliptical plates in its walls . . . . 40.

40. Chitinised spots in the walls of the ductus bursae arranged in a definitely spiral band, those at the edge of the band being larger than those in its centre. Ostium bursae simple. The fan of modified scales arises from chitinised strips in the membrane between the eighth and seventh sternites . . . . *E. afflatella*, Mn.

— Chitinised spots in the walls of the ductus bursae not arranged in a very definite spiral, those in the neighbourhood of the bursa being the largest.

Ostium bursae enlarged and thickened (probably bearing modified scales which are detached in making a microscopic mount). A definite lobe (probably bearing modified scales) on each side of the seventh sternite just before its posterior margin . . . . *E. disputella*, sp. n.

THE LIFE-HISTORY AND EARLY STAGES OF THE SPECIES OF *EPHESTIA* AND *PLODIA*.

Very little is known of the life-histories and habits of species * of these genera apart from those which infest stored products. This is unfortunate and much restricts speculation as to how and why some species became pests. The life-histories of the stored products species are all very similar and the recorded data, still unfortunately by no means complete, are given in tabular form in the following paragraphs. Structurally, also, the early stages are much alike and are most easily dealt with comparatively. The species which are pests of stored products have usually a wide range of foods, but as the most important foods tend in each case to be rather different, the records are given separately under each species.

(1) *The Adult Moths.*

The adults of the species of *Ephestia* and *Plodia* are all essentially nocturnal. Specimens of the out-of-door species are mostly captured when attracted to light, while the domestic species prefer the darker corners of warehouses, etc., where they sit about on the walls or on the stored products during the day, and only become really active at night. In the case of *E. kühniella*, Bremer (1926) found that a high proportion of the moths emerge in the afternoon and evening. He was able to show experimentally that light is an important factor in the control of this reaction, while Kühn and Henke (1929, p. 43) have found that temperature also influences the time of emergence. Brindley (1930), however, states that there is no definite time of emergence in a constant environment. Both sexes are ready for pairing a very short time after emergence, almost as soon as the wings are dry. Virgin females, when ready for pairing, begin "calling." In this activity the moth sits with its wings folded up and the apical half of its abdomen bent over its back between them. Meanwhile the apical abdominal segments are alternately exserted and retracted, so that the intersegmental membranes are widely exposed. There is little doubt that during this process a scent attractive to the males is emitted; the segmental membranes, especially in the neighbourhood of the orifice of the ductus bursae, have an appearance strongly suggesting the presence of secretory tissues. Males become very excited in the presence of these calling females and we have found that even a pillbox from which a calling female has recently been removed has the same effect. The male begins fluttering round the female, who at first appears to take little notice or even runs away. Eventually she comes to a standstill and the male stands facing her, head to head, and bends his abdomen over his back to grip the tip of the female abdomen. Almost immediate the pair twist round so as to be tail to tail. The females usually mate once only, though not rarely twice, while the males mate repeatedly until with old age they become too weak to grip the female effectively. According to Brindley (1930) copulation in *E. kühniella* lasts for 4–6 hours. The adult moths live from one to three weeks, the exact period depending on the temperature and other factors. *E. kühniella* is rather longer lived than *Plodia* or *E. elutella.* In *E. kühniella* the males live rather longer than the fertilised females. Virgin females live as long as males. Janisch (1924*a* and *b*) has studied the factors governing senescence in *E. kühniella* and other insects and has shown the importance of temperature and CO_2 concentration.

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* Except *E. parasitella*, Stdgr., *E. rileyella*, Rag. and *E. woodiella*, sp. n., of which the food or some slight details of the life-history are known.

(2) *The Eggs.*

The eggs are laid from the first night after mating on or near the food, often in crevices and usually in dark places. Normally they are scattered about irregularly, more rarely a considerable number are laid close together. In *E. kühniella,* Hase (1928) records that eggs are sometimes laid in a chain, each egg being attached obliquely to the end of the adjacent ones, so that a regular zigzag is formed. These chains are produced by females which are being slowly poisoned, *e.g.* by too high a concentration of CO_2. Unfertilised females usually lay a reduced number of eggs and none of these hatch. Fertilised females during a week or rather more lay a large but variable number of eggs as may be seen in the following table.

TABLE I.

The number of eggs laid.

E. kühniella, Z. Decaux (1893), average 200–250; Johnson (1895*b*), average 240 (120–271); by dissection 187–342 eggs were found and of these not more than 26, and usually much fewer, were unlaid: Frickhinger (1918), 124–322; Burkhardt (1919), 75–320, usually 150–200; Candura (1928), 119–280, average 200; Brindley (1930), 25–352, average 167. Observations made in this laboratory show 200–500 eggs, usually 300–400.

E. calidella, Gn. According to Gough (1918) one female laid 192 eggs.

Plodia interpunctella, Gn. Popenoe (1911), 300–400; Parker (1915), 156–250; Myers (1928), 200–400.

The incubation period of the eggs differs somewhat in the species and varies with the temperature. Hase (1927) has studied the latter effect in more detail in the case of *E. kühniella.* The following data have been recorded or observed.

TABLE II.

The incubation period of the eggs.

E. kühniella, Z. According to Candura (1928), 4 days at 25–6° C.: 6 days at 22–3° C.: 9–11 days at 20–1° C.: 37 days at 10–13° C. 96 hours at 29·7° C., according to Brindley (1930).

E. elutella, Hb. Personal observations, 6–10 days, average 6·8 days, at a temperature of 22–4°, average 23° C.

E. cautella, Wlk. Personal observations, about 5 days at 26° C. According to Chittenden (1911), 3½–14 days at 29° C.

E. calidella, Gn. According to Gough (1918), 4 days, in Egypt.

P. interpunctella, Gn. Personal observations, 4–9 days, average 5·1, at a temperature of 25–8°, average 26° C. According to Hill (1928), 1–2 days at 32–35° C.: 5–14 days at 15·5–18·5° C. According to Myers (1928), 1–18 days according to temperature.

The specific differences in the eggs of *Ephestia* species appear to be small. The eggs are white, somewhat iridescent (especially the empty shells), with the surface finely granulate. In *E. cautella* these granulations are larger and each one has a more obvious series of small radiating keels. Gough (1918) records the same structure in the egg of *E. calidella.* The shape is ovoid from one and a third to nearly twice as long as broad. The eggs have the following dimensions in the various species.

TABLE III.

Size of the eggs.

E. kühniella, Z. Durrant and Beveridge (1918), 0·58 × 0·31 mm. : Burkhardt (1919), 0·56 × 0·29 mm. : Johnson (1895*b*), 0·441 × 0·222 mm. : Brindley (1930), 0·58 × 0·33 mm. Personal observations, average 0·57 × 0·30 mm.
E. elutella, Hb. Personal observations, average 0·6 × 0·32 mm.
E. cautella, Wlk. Personal observations, average 0·43 × 0·29 mm.
E. calidella, Gn. Gough (1918), 0·4 × 0·36 mm.
P. interpunctella, Gn. Personal observations, average 0·49 × 0·28 mm.

Thus the eggs of *E. cautella* and *E. calidella* are considerably, and of *Plodia* somewhat, broader than those of the other species. In the case of at least *E. kühniella* the eggs laid towards the end of the female's laying-period tend to be smaller, and this may account for the discrepancy in Johnson's measurements. According to Brindley (1930) the eggs of *E. kühniella* weigh on the average 0·023 mg.

(3) *The Larvae.*

The young larvae at the time of emergence are just visible to the naked eye and at once begin to attack the food available, making small galleries of silk and frass. The egg-shells are not usually eaten, but in the absence of other food, both the shells and even any unhatched eggs may be devoured. Dead bodies of adult moths are also usually eaten even in the presence of other food. A short time before each moult feeding stops and the larva becomes restless, often leaving its food. In *Ephestia* moulting often takes place beneath a slight silken shelter, but in *Plodia* the larva remains on its food. The number of moults is slightly variable even in larvae kept under identical conditions and is apparently independent of sex. Burkhardt (1919) found that in *E. kühniella* there was often an extra moult when the temperature was low. Kühn and Henke (1929) in the same species have studied the factors controlling the length of the life-history. Temperature, food-supply, the nature of the food and, to some extent, hereditary constitution, are important; sex, however, has no influence. In the following table details of the life-history, including the number of moults and the length of the pupal period, are set out. Under "total life-history" is included the whole period from the laying of the first eggs to the emergence of the first adults. In the case of our personal observations we treat the sexes separately, but this is not possible as a rule in published data.

Numerous authors, especially those writing towards the end of the last century, have described the larvae of *Ephestia* and *Plodia.* Most of the descriptions refer only to colour and size and would apply equally well to almost

TABLE IV.

Number of moults and the length of the life-history.

Species.	Observer.	Temperature.	No. of moults.	Time in days to first moult.	From 1st to 2nd moult.	From 2nd to 3rd moult.	From 3rd to 4th moult.	From 4th to 5th moult.	From 5th to 6th moult.	From 6th to 7th moult.	From last moult to pupation.	Length of pupal period.	Total life-history.
E. kühniella, Z.	Burkhardt (1919).	"Warm."	3–4, usually 3.	7–8.	Second moult when 16–23, usually 20–23 days old.	3rd moult when 33–46, usually 40–46 days old.	—	—	—	—	Pupate when 50–70 days old.	18–30.	2½–3 months.
"	Johnson (1895*b*).	—	—	—	—	—	—	—	—	—	Active period of larva about 41 days.	14	60–70 days.
"	Brindley (1930).	29·7° C.	5.	5–7, average 6.	3–5, average 4.	4–5, average 4.	3–6, average 4.	4–6, average 4.	5–12, average 7.	—	—	7–10, average 8.	41 days.
E. elutella, Hb.	Personal obs.	22–24°, average 23° C.	5–7, usually 5.	8–24, average 13·7.	9–33, average 11·5.	11–31, average 16·7.	9–33, average 18·9.	10–41, average 20·6.	17–34, average 22·7.	28 (one record).	—	8–42, average 14·1.	250–300 days.
E. calidella, Gn.	Gough (1918).	Egypt in Sept.	—	—	—	—	—	—	—	—	shortest larval period 20–21 days.	5.	25–38 days.
E. cautella, Wlk.	Personal obs.	25–28°, average 26° C.	4 in ♂.	2 ♂♂ { 5, 5.	4, 5.	5, 6.	7.	—	—	—	46.	11.	70 days.
"	"	"	5 in ♀.	8 ♀♀ { 5–6, average 5·5.	4–6, average 4·75.	5–6, average 5·5.	4–7, average 6.	4–9, average 6·1.	—	—	4–56, average 27·4.	8–10, average 9·7.	
"	Chittenden (1911).	29° C.	—	—	—	—	—	—	—	—	larval period 13–30 days.	8½–24 days.	—
P. interpunctella, Hb.	Personal obs.	25–8°, average 26° C.	♂♂ { 13 spec. 4. 5 spec. 5.	5–10, average 7·7.	4–8, average 5·1.	3–9, average 5·3.	4–8, average 6.	5–8, average 6·1.	—	—	10–38, average 17·4.	5–12, average 10.	35–50 days.
"	"	"	♀♀ { 10 spec. 4. 8 spec. 5. 1 spec. 6. 1 spec. 7.	6–10, average 7·8.	4–9, average 5·6.	4–12, average 6·0.	4–14, average 6·8.	5–14, average 8·4.	9–21, average 14·3.	14.	2–73, average 25·8.	8–12, average 9·8.	

any species, the colour of the larva being variable in these genera. The following are some of the papers in which larvae are described :—

Plodia interpunctella, Hb. Porritt (1880*a*), Riley (1889).
Ephestia kühniella, Z. Riley (1889).
E. elutella, Hb. Buckler (1874), Bignell (1894), Vecchi (1927). The last-named author has given the only detailed description of a larva of this genus.
E. cautella, Wlk. Buckler (1882).
E. figulilella, Gregs. Porritt (1880*b*).
E. woodiella, sp. n. (*semirufa*). Wood (1888).

Fracker (1915) in his key to Lepidopterous larvae gives (p. 90) the characters separating the larvae of *Plodia* and *Ephestia*. According to Fracker, the front in *Plodia* extends about two-thirds of the distance to the vertical triangle, the boundary of the adfrontals meeting the epicranial suture about halfway between the front and the vertical triangle. In *Ephestia* the front is said to extend about halfway to the vertical triangle, and the boundaries of the adfrontals to meet the epicranial suture at a point about twice as far from the vertical triangle as from the front. According to our observations there is no difference between the larvae of *Plodia* and *Ephestia* in the characters given by Fracker. Fig. 123 shows the dorsal view of the head of the larva of *E. kühniella*; those of *E. cautella, E. elutella, E. calidella* and *Plodia* are all quite similar. Fracker further states that the crotchets of *Ephestia* are triordinal, whereas we find them to be biordinal.

The larva of *Plodia* can, however, be distinguished from those of *Ephestia* species by the absence of the small, chitinised spots from which, in *Ephestia*, the bristles arise on the dorsal surface. On the ninth abdominal tergite the spots are so large in *Ephestia* as to form small plates, while in *Plodia* they are practically absent, even here. The colour of *Plodia* larva is usually dead white, while in *Ephestia* (except most specimens of *E. kühniella*) it is often pinkish, but this difference is sometimes inappreciable. The following key will help to separate the larvae of the species we have examined, though exceptional individuals are liable to occur. In the nomenclature of the bristles we have followed Fracker (1915). Setal maps are shown in figs. 125–8. There are no specific differences.

1. Bristles α, β and ρ not arising from chitinous plates on the ninth segment *P. interpunctella*, Hb.
– These bristles arising from definite chitinous plates on the ninth segment. All dorsal bristles arising from more or less definite chitinous spots . . 2.
2. Bristles σ and π on the seventh abdominal segment with no or practically no chitinous bases . . . . 3.
– Bristles σ and π with definite, small chitinous bases . . . . 4.
3. Colour whiter. Bristles κ, η and μ on the ninth segment arising from a fairly definite chitinous plate . . . . *E. kühniella*, Z.
– Colour pinkish. Bristles κ, η and μ on the ninth segment arising from an area which is scarcely chitinised . . . . *E. calidella*, Gn.
4. Bristles π on the proleg-bearing segments not arising from chitinised areas. Dorsal chitinised spots weaker . . . . *E. elutella*, Hb.
– Bristles π on the proleg-bearing segments arising from definite chitinised areas. Dorsal chitinised spots stronger . . . . . *E. cautella*, Wlk.

Klein (1887*b*) was the first to notice the sex-mark which appears in mature *Ephestia* larvae, but he supposed it to be the larva of a parasitic Hymenopteron.

Poulton (1888) and Danysz (1893*a*) have pointed out its true significance. In the mature male caterpillar the gonad shows through the integument of the anterior half of the fifth abdominal segment as a brown or blackish dorsal mark.

In the larva of *Plodia* the prothoracic plates first appear after the second moult; the adfrontal plates on the head are defined after the fourth or fifth moult. In the male the sex-mark appears after the fourth moult.

In the larva of *E. cautella*, the prothoracic plates are visible at hatching. The dorsal series of spots is not visible in the first stage, but begins to be so after the first moult. The sex-mark appears after the fourth moult.

In the larva of *E. kühniella*, Brindley (1930) records the weight and the width of the head capsule of each instar.

The appendages of the head, though quite complex in structure, are on the whole very uniform in the different species. Our figures (Pl. XII) show the antennae and mouth-parts of *E. elutella* and *Plodia*. The parts may be considered in order.

(*a*) The antennae. These are very similar to those of *Plodia* (fig. 115), except in the case of *E. calidella* (fig. 116).
(*b*) The mandibles. There are no very striking differences in the mandibles. They are similar to *E. elutella* (fig. 117) in *E. calidella* and *E. cautella*, though in the latter species the two central apical teeth are stronger. In *E. kühniella* there are only two distinct apical teeth.
(*c*) Labrum. The labrum is rather more deeply emarginate in *Plodia* (fig. 118) than in the species of *Ephestia*.
(*d*) The maxillae (figs. 119, 120). These appear to be identical in all the species examined.
(*e*) The labium. The base of the labium is surrounded by a strong chitinous ring (1, fig. 119). This is broad and complete in *E. elutella*, *E. cautella* and *E. calidella*.
(*f*) In *Plodia* (fig. 122) the ring is narrower and open anteriorly. In *E. kühniella* it is narrow, much more elongate and open anteriorly.

(4) *The Pupae.*

The duration of the pupal period has been considered in the previous section (Table IV). The pupa is usually enclosed in a slight cocoon, spun up in a crevice, but some individuals, especially in captivity, pupate without making a cocoon. Before spinning up the larvae have a restless period during which they wander from their food, usually travelling upwards. Most individuals travel up the walls, but others travel up the sacks of food and the topmost sack of a pile will always be found to be covered with such larvae. It is at this period that the larvae are particularly difficult to confine in cages. Klein (1887*a*) who was breeding *E. kühniella* in his house found it impossible to stop them escaping and had to get rid of them. Johnson (1895*b*) maintains that the larva of *E. kühniella* is never responsible for holes bitten in the bolting cloth of flour-mills; we have found, however, that in the wandering period they will bite through the muslin covers of their cages. When the larvae are very numerous the trails of silk which they leave behind them eventually become woven into a compact fabric, resembling chamois leather in appearance. This fabric is sometimes found in sheets of enormous size, *e.g.* Trelease (1896) records a sheet 20 × 80 yards found on the ceiling of a granary in Mexico. This was made by larvae of *E. kühniella*. An anonymous author (1878) exhibited part of a similar sheet made by the larvae of *E. elutella* in a chicory warehouse in York. A piece 8 × 4 feet was obtained and, since the individual threads were less than $\frac{1}{5000}$ inch thick, the piece represented many hundreds of miles wandering. Hase (1924*b*) has discussed the silk-production of the larvae of *E. kühniella*.

The sex (figs. 129–30) of a pupa of *Ephestia* or *Plodia* may be determined as follows. The rudiments of the genital and anal apertures appear as short, longitudinal thickenings on the mid-ventral line, the anus being on the tenth segment, the male genital aperture on the ninth, and the female on the eighth. Furthermore, in the female the posterior margin of the eighth sternite is deeply and angularly emarginate, while in the male this margin is straight; this character is not so marked in *Plodia*.

Mosher has figured (1916, pl. 24, fig. 74) the pupa of *E. kühniella*. The characters she gives (p. 75) for separating the genera *Ephestia* and *Plodia* are not reliable. The punctate abdominal tergites are found only in *E. kühniella*, while the maxillae in that species do not, in our experience, reach the caudal margin of the wings. We have examined the pupae of the following species :— *E. kühniella*, *E. cautella*, *E. elutella* and *Plodia interpunctella*. We have drawn up a key to separate these species, but it is probably not absolutely reliable, since the characters are to some extent variable, especially in *Plodia*. A certain proportion of the pupae are always more or less malformed; these may be impossible to determine.

1. Pronotum and fronto-clypeus rugose. (7–9, usually 7, cremastal hooks. Maxillae (cf. fig. 129) ending one-third of their length before the apex of the third pair of legs. The base of the third pair of legs hidden by the second pair, the exposed part being triangular and four to five times longer than broad at the apex. Antennae ending distinctly before the second pair of legs.) . . . . *E. kühniella*, Z.
– Pronotum and fronto-clypeus smooth . . . . 2.
2. Maxillae ending one-third of their length before apex of third pair of legs, the exposed part of which is about six times as long as broad. (Antennae ending near apex of wings.) . . . . *E. calidella*, Gn.
– Maxillae longer . . . . 3.
3. Maxillae ending about one-fifth of their length before the apex of the third pair of legs, the exposed part of which is usually about five times as long as broad. (7–8 cremastal hooks. The antennae usually ending well before end of wings.) . . . . *Plodia interpunctella*, Hb.
– Maxillae extending considerably farther; exposed part of the third pair of legs nearly always less than three times as long as broad. 6–7, usually 6, cremastal hooks . . . . 4.
4. The exposed part of the third pair of legs usually about twice as long as broad. Antennae continued to the end of the wings . . *E. elutella*, Hb.
– The exposed part of the third pair of legs about as long as broad. The antennae end distinctly before the wings . . . . . *E. cautella*, Wlk.

(5) *The Number of Annual Broods.*

There is no information as to the number of broods a year obtaining in species of *Ephestia* leading a purely out-of-doors existence. These species are usually captured at light; as far as the dates of capture go, it is not likely that they have more than one or two broods a year. As regards the stored products species (except *E. kühniella*), the information collected by Barrett (1905) shows that under the conditions of English warehouses there is one main brood in the summer and a partial one in the autumn. Perhaps as a result of artificial conditions, the generations are very irregular (especially in *Plodia* and *E. elutella*), while constant introductions of all stages in produce from abroad still further obscures the broods. *E. kühniella*, which only regularly maintains itself in heated flour-mills, appears to have at least three broods a year. In the warmer conditions of Asia Minor or California there is no doubt that the species have more broods in the year though emergence is so continuous as to make their limits indefinite. Unfortunately most of the information consists of records of the length of the life-history under laboratory conditions with a deduction as to the number of generations which should therefore occur in nature. It is by no means certain, however, that in nature the moths produce the number of generations that would be expected in theory. Under artificial conditions a stock often multiplies very rapidly for a time and then gradually dies out, as found in the case of *E. kühniella* by Kühn and Henke (1929), who regard both inbreeding and too high a temperature as contributory causes. It is quite possible that in nature the number of broods would be fewer and that sterility would not then intervene. The subject is still very obscure and cannot, perhaps, be elucidated by experiments conducted solely under laboratory conditions.

The following data have been recorded :—

E. kühniella, Z.

Germany. 3 generations a year; systematic collections of adults shows that this stage is very abundant from May–October, much less so in the other months—Burkhardt (1919).
France. 2–6 generations according to the varying temperature in different parts of the mill—Danysz (1893*b*).
Italy. 2–5 generations, according to the food—Candura (1928).
Belgium. Probably two generations—Girard (1884).
California. 5–6 generations—Johnson (1895*b*).

E. elutella, Hb.

Germany. More than one generation a year, but the division into broods is not well marked—Reh (1907). 1–2 generations a year—van Emden (1925*b*).

E. cautella, Wlk.

U.S.A. 2–6 generations a year according to temperature—Chittenden (1911).

Plodia interpunctella, Hb.

Germany. 1–2 generations—van Emden (1925*b*).
Australia. Probably 2 generations—Myers (1928). 2–3 broods—Hill (1928).
U.S.A. 6 generations or more in a heated granary; 4–5 in a cooler granary or warehouse—Chittenden (1897*b*).

(6) *Hibernation.*

Hibernation appears to take place in either the larval or the pupal stage, especially the former. According to Hill (1928), *Plodia* hibernates in Australia as a larva only and there is considerable mortality during this period. Under artificial conditions of warmth, hibernation scarcely takes place, while even in cool warehouses, a few adults are liable to be found during the winter.

The Parasites and Predators of the Early Stages of *Ephestia* and *Plodia*.

HYMENOPTERA : Ichneumonidae.

Nemeritis canescens, Grav.

canescens. 1829 : Gravenhorst, 555 (*Campoplex*). 1887 : Thomson, 1120 (*Nemeritis*). 1911 : Schmiedeknecht, 1688. 1914 : Morley, 133; Durrant. 1919 : Burkhardt. 1920 : Krüger. 1921 : Smits van Burgst; Waterston. 1922 : Champlain. 1926 : Dieuzeide. 1927 : Voinoskaya-Kriger. 1928 : Candura; Whiting. 1929 : Candura; Myers. 1930 : Daviault. 1931 : Schütze and Roman.
frumentarius. 1874 : Rondani, 134 (*Campoplex*). 1877 : Rondani, 169. 1897 : Chittenden, *a* (*Omorga*). 1905 : Newell and Smith (*Omorga*). 1911 : Chittenden (*Omorga*); Popenoe (*Omorgus*). 1921 : Waterston (*Campoplex*). 1929 : Dunham, fig.
oahuensis. 1901 : Ashmead, 355 (*Idechthis*).
? *litoreus.* 1911 : Berliner, 63, nec *Omorga litorea*, Thomson (1887, 1134).
fulviventris. 1911 : Theobald (*Olesicampa*) *nec* Gmelin.
ephestiae. 1912 : Cameron, 187 (*Amorphota*); Froggatt.
prytanes. 1930 : Richards and Herford, 383 (*Campoplex*) *nec* Cameron.

The first definite host record is that of Chittenden (1897*a*), who recorded *N. canescens* from *E. kühniella* and *E. cautella* (*cahiritella*). Since that date many authors have bred it from the first-named host, and Myers (1929) also records *E. cautella* as a probable host. Candura (1929) records *Plodia interpunctella*, and probably any species of *Ephestia* is liable to attack. The parasite, however, being mainly found in flour mills, comes mostly into contact with the larvae of *E. kühniella*, its main host. Richmond (1925) found it in beehives in Colorado, where it was parasitising the larvae of *Galleria mellonella*, L. Rondani (1874, 1877) records it, with some doubt, from the larvae of *Tinea granella*, L.; it is possible that some species of *Ephestia* or *Plodia* was really present with the *Tinea*.

There is no record of the occurrence of the male of the parasite. Schmiedeknecht (1911) and Morley (1914) quote Thomson (1887) as having seen the male. Actually, Thomson does not record the sex of his specimens at all. Whiting (1928) bred 3953 females without obtaining a male and Voinoskaya-Kriger (1927), by whom the best study of the life-history has been made, found the receptaculum seminis absent. According to her account the host-larvae are mainly attacked in the intermediate stages; older larvae, if attacked, can proceed with pupation and may even succeed in emerging. The larvae are stung through the web which they spin over themselves, exposed larvae being less easily gripped by the parasite. Stinging does not lead to even a momentary paralysis. Usually only one egg is laid on each host. The complete life-cycle takes from 18 to 34 days, with an average of 23 days at a temperature of 20 to 25° C. Daviault (1930), however, found a life-history of 27–30 days at 28° C. Pupation takes place within the host-web, or host-pupa. Under natural conditions there may be 15 generations in the year, but this would be under ideal conditions. Seven per cent. of the *E. kühniella* larvae parasitised by *N. canescens* were hyperparasitised by *Lariophagus distinguendus*, Först. (Pteromalidae).

N. canescens has by now, probably, been spread all over the world by *E. kühniella.* The recorded range includes England, Holland, Germany, South Europe, North Africa, Asia Minor, Japan, Sandwich Islands, Australia and North America.

Limneria ephestiae, Ashmd.

ephestiae. 1896 : Ashmead, 195 (*Limneria*). 1897 : Chittenden, *a*. 1901 : Fletcher (*Idechthis*) ?. 1911 : Chittenden (*Limneria*) ?. 1921 : Waterston.

This species was described originally from specimens reared from unknown larvae, doubtfully considered to be those of *Plodia interpunctella* (*Ephestia zeae*), feeding on wax in a beehive. Chittenden (1911) records it uncertainly from the larvae of *Ephestia cautella*, and Fletcher (1901), if the name he employs really refers to this species, from the larvae of *E. kühniella*. It is very probable that these records, except perhaps the original one, really refer to *Nemeritis canescens*, Grav. *L. ephestiae* has only been recorded from the United States.

Omorgus columbianus, Ashmd.*

Omorga columbiana (Ashmead), Johnson (1899), Burkhardt (1919).

Little appears to be known of this species, which was bred by Johnson from *E. kühniella* in U.S.A.

Angitia incipiens, Walley.

incipiens. 1929 : Walley, 192 (*Angitia*).

This species was described from Canada, having been found in a room where *E. kühniella* was being bred. Its real host is very doubtful.

Mesostenus gracilipes, Cress.

gracilipes. 1878 : Cresson, 365 (*Mesostenus*).
gracilis. 1899 : Johnson (*Mesostenus*). 1919 : Burkhardt.

This species was also bred by Johnson from *E. kühniella* in U.S.A.

BRACONIDAE.

Microbracon hebetor, Say.

hebetor. 1836 : Say, 252 (*Bracon*). 1895 : Johnson, *a* and *b* (*Bracon*). 1897 : Chittenden, *a* (*Bracon*). 1899. Johnson (*Habrobracon*). 1910 : Buchwald and Berliner (*Habrobracon*). 1911 : Chittenden (*Hadrobracon*); Popenoe (*Hadrobracon*). 1912 : Froggatt (*Bracon*). 1921 : Waterston (*Habrobracon*). 1925 : Muesebeck, 31 (*Microbracon*). 1926 : Zacher. 1929 : Dunham, fig.; Hagan; Munro and Thomson; Myers; Simmons and Reed.
honestor. 1895 : Howard, *a* (*Bracon*) *nec* Say.
brevicornis. 1884 : Kirby (*Bracon*). 1885 : Marshall (*Bracon*) in part. 1888 : Billups (*Bracon*); Marshall (*Bracon*) in part. 1893 : Danysz, *a* (*Bracon*). 1896 : Schmiedeknecht (*Bracon*) in part. 1906 : Szépligeti (*Habrobracon*). 1913 : Durrant and Beveridge (*Bracon*). 1914 : Cushman (*Habrobracon*). 1919 : Burkhardt (*Bracon*). 1921 : Waterston (*Habrobracon*); Smits van Burgst (*Habrobracon*); Whiting, *a* (*Hadrobracon*). 1922 : Hase (*Habrobracon*). 1928 : Fahringer (*Habrobracon*) in part. 1929 : Tosi *nec* Wesmael.
juglandis. 1889 : Ashmead, 821 (*Bracon*). 1897 : Chittenden, *a* (*Bracon hebetor* var.). 1911 : Doten, 24–9, pl. 9 and 10. 1922 : Cushman (*Habrobracon*). 1923 : De Ong (*Hadrobracon*); Hase (*Habrobracon*). 1924 : Hase, *a* (*Habrobracon*). 1925 : Hase, *a* (*Habrobracon*). 1926 : Frison; Schlöttke (*Habrobracon*). 1927 : Kühn (*Habrobracon*). 1928 : Fahringer (*Habrobracon*); Myers (*Habrobracon*); Showell (*Habrobracon*).
beneficientior. 1911 : Viereck, 182 (*Habrobracon*).

The nomenclature of this species has suffered as much confusion as that of perhaps any other species of Hymenoptera. In the first place two species, *Microbracon hebetor*, Say, and *M. brevicornis*, Wesm., were not recognised as distinct until Cushman (1922) and finally Muesebeck (1925) pointed out the differences, which consists mainly in the number of antennal segments. It has now been established that *M. hebetor* is mainly a domestic species, except, perhaps, in some of the hotter parts of its range, and that it parasitises various

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* Ashmead never, apparently, described this species.

Lepidopterous larvae which attack stored products. *M. brevicornis* is a very closely allied form which lives out of doors and attacks various Lepidopterous larvae, especially those of *Pyrausta nubilalis*, Hb. It only comes into contact with species of *Ephestia* in the warmer parts of their range.

Another source of confusion is the great variation in colour to which *M. hebetor* is liable (see Whiting, 1921*b*). The physiology of this variation has been studied by Génieys (1922) in the case of *M. brevicornis*, Wesm., and by Schlöttke (1926) and Kühn (1927) in the case of *M. hebetor*. They have shown that at low temperatures black pigments become dominant, while at higher temperatures the black is more and more reduced, till finally entirely yellowish forms are produced. Further, those parts of the body to which muscles are attached or with which large nervous masses are in contact, are less responsive to heat than the other parts of the body.

It is evident, therefore, that differences in colour are of almost no value in defining species. Probably a number of the species described by Ramakrishna Ayyar (1928) will prove to be synonyms of either the present species or of *M. brevicornis*, Wesm.

The following hosts have been recorded for *M. hebetor*, only one author being quoted here to substantiate each host record :—

Marshall (1888), *Ephestia kühniella*, *E. elutella* and doubtfully *Myelois ceratoniae*; Chittenden (1897*a*), *E. cautella*, *Plodia interpunctella*; Cushman (1922), *Galleria mellonella*, L.; De Ong (1923), *Paralipsa* (*Aphomia*) *gularis*, Zell.; Muesebeck (1925), *Vitula edmandsii*, Pack., *Sitotroga cerealella*, Ol. Of these, *Plodia* and the species of *Ephestia* are by far the most common hosts.

The life-history of *M. hebetor* has been studied by Doten (1911), Whiting (1921*a*), Hase (1922, 1923, 1924*a*, 1925*a*), Showell (1928) and Myers (1929). The ♀ only oviposits on larvae over 10 mm. in length, though smaller ones may be stung. After a short interval the sting of the parasite paralyses the host larva, which does not, however, react much at the actual moment when the puncture is made. Normally the female *Microbracon* paralyses a number of larvae and then returns afterwards to oviposit on some of them. Under warehouse conditions often only a small proportion of the parasitised larvae actually have eggs laid on them. The paralysis is always fatal, though life may continue for nearly a month. The female usually turns round and feeds for some time on the juices which exude from the puncture made by her oviposition (see Doten, 1911). Usually 2–5 eggs are laid on each host, but sometimes as many as 14, in which case the resulting adults are very small. Except under very abnormal conditions, fertilised eggs always give rise to females, unfertilised to males. The incubation period varies from half a day (at 32–4° C.) to 8 days (at 4–14° C.). There are four larval stages, the larval period lasting for from 1½–5 days, according to temperature. The adult larvae spin small, white cocoons, the larvae from one host usually spinning up in fairly close contact, either on or near the remains of the host. The pupal period, which lasts from 3 days (at 32° C.) to 30 days (below 16° C.), averages 14 days at room temperature, and is preceded by a short pre-pupal period. In one of Hase's experiments 28 fertilised females gave 598 ♀♀ and 706 ♂♂, *i.e.* an average of 46 offspring per female; the maximum number of eggs laid, however, was 317, of which under good conditions about 60 per cent. hatch. In a semi-large-scale experiment, Hase found that on the average a 57 per cent. control of *E. kühniella* could be obtained with *M. hebetor*.

In England *M. hebetor* passes the winter as a pupa, the adults disappearing after October and not becoming common again until late June. In S. Australia, however, Showell found that a few females hibernated through the winter. Doten (1911) records that females fed on sugar and water will live for several months, while in cold storage at a temperature near freezing point they survive for four months. *M. hebetor* is now cosmopolitan; the range includes Europe, Africa, Asia Minor, Australia and North America.

Microbracon brevicornis, Wesm.

brevicornis. 1838: Wesmael, 23, fig. 2 (*Bracon*). 1885: Marshall (*Bracon*) in part. 1888: Marshall (*Bracon*) in part. 1896: Schmiedeknecht (*Bracon*) in part. 1922: Cushman (*Habrobracon*). 1925: Génieys (*Habrobracon*); Muesebeck, 33 (*Microbracon*).
vernalis. 1901: Szépligeti (*Bracon*). 1928: Fahringer (*Habrobracon*).
kitcheneri. 1913: Willcocks (*Rhogas*). 1914: Dudgeon and Gough (*Rhogas*); Gough (*Rhogas*). 1916: Dudgeon and Gough (*Rhogas*); Gough (*Rhogas*); Willcocks (*Rhogas*). 1922: Ramachandra Rao (*Habrobracon*). 1924: Husain and Mathur (*Bracon*). 1928: Fahringer (*Habrobracon*).
lefroyi. 1914: Dudgeon and Gough (*Rhogas*). 1920: Brues (*Microbracon*). 1921: Husain and Mathur (*Microbracon*). 1924: Husain and Mathur (*Bracon*).

It seems rather doubtful whether *M. kitcheneri* and *M. lefroyi*, especially the latter, are really synonyms of *M. brevicornis.* Assuming, however, that they are, the following hosts have been recorded for *M. brevicornis* :—

Marshall (1888), *Dioryctria abietella*, F., and galls of *Biorrhiza pallida*, Ol. (*Andricus terminalis*, F.), in the latter case the real host perhaps being a Lepidopterous larva; Willcocks (1916), probably *Pectinophora* (*Gelechia*) *gossypiella*, Saund., and *Pyroderces simplex*, Wlsm.; Gough (1916*b*), *E. cautella*, Wlk., and *Earias insulana*, Boisd.; Ramachandra Rao (1922), *Batrachedra amydraula*, Meyr.; Husain and Mathur (1924), *Phycita infusella*, and *Nephopteryx* sp.; Muesebeck (1925), *Pyrausta nubilalis*, Hb.; King (1928), *Diparopsis castanea*, Hmpsn., *Pectinophora gossypiella*, Saund., and *Sesamia cretica*, Led.; Kotlán (1929); *Vanessa io*, L. Pospelov (1924) bred it experimentally on *E. kühniella.* Génieys (1925) gives a long list of hosts on which he experimented, including *Acrobasis obliqua*, Z., *Carpocapsa splendana*, Tr., *Diatraea zeacolella*, F., *Leucania zeae*, Dup., *Nothris senticella*, Stdgr., *Phthorimaea operculella*, Z., *Sesamia nonagrioides*, Lef., and *Tortrix viridana*, L. In addition he quotes *Grapholitha rufillana*, Stt., as a host. Coleopterous larvae were ignored by ovipositing females, while the following Lepidopterous larvae would not support the parasite if eggs were laid :—*Aporia crataegi*, L., *Liparis dispar*, L., and *Pieris brassicae*, L. The life-history, as shown by Génieys, does not differ essentially from that of *M. hebetor.* It will not be given in detail here since *Ephestia* is only a relatively unimportant host, and then only in countries like Egypt where the moth maintains itself out of doors.

The range includes Europe, especially the south, Egypt, and probably India; it is being imported into N. America to control the Corn-borer.

Opius carinatus, Thomson.

A variety of this wasp is recorded as a parasite of *Plodia interpunctella*, Hb., by Tosi (1929).

Apanteles ephestiae, Baker.

ephestiae. 1895: Baker, 201 (*Apanteles*). 1897: Chittenden, *a.* 1919: Burkhardt. 1921: Waterston.

Described by Baker from "*E. kühniella* working in the honey-comb." It is very improbable that the host really was *E. kühniella.*

Chremylus rubiginosus, Nees.

rubiginosus. 1834: Nees, 156 (*Hormius*). 1888: Marshall (*Chremylus*). 1890: Riley. 1895: Johnson, *a* and *b*. 1897: Chittenden, *a*. 1919: Burkhardt. 1921: Waterston.

Riley quotes J. Bridgman, of Norwich, England, to the effect that *C. rubiginosus* is a parasite of *E. kühniella.* Marshall, however, gives *Bruchus* spp. and *Tinea pellionella,* L., as the hosts and Chittenden adds *Ernobius,* so that it is very unlikely to be a normal *Ephestia* parasite. Johnson (1895*b*) incorrectly states that Riley's record was based on American specimens.

Diachasma sicula, De Stef.

Recorded by De Stefani (1919*b*) as a parasite of *E. cautella* in Italy.

CHALCIDIDAE.

Lariophagus distinguendus, Först.

According to Voinoskaya-Kriger (1927), 7 per cent. of the larvae of *E. kühniella* parasitised by *Nemeritis canescens,* Grav., were hyperparasitised by *L. distinguendus.*

Trichogramma evanescens, Westw.

According to Hase (1925*b*) and Evans (1930), this parasite can be reared on the eggs of *E. kühniella.*

Trichogramma minutum, Riley.

Flanders (1930) has bred this parasite on the eggs of *E. cautella.*

Dibrachys cavus, Walk. (**boucheanus,** Nees.).

De Stefani (1919*b*) bred this fly-parasite from the larvae of *E. calidella* and *Plodia interpunctella.* He also gives the following further stored products insects as hosts :—*Sitotroga cerealella,* Ol., *Myelois ceratoniae,* Z., and *Sitodrepa panicea,* L.

Spilochalcis, sp.

Pierce and Morrill (1914) bred a wasp of this genus from the larva of *Ephestia* sp. in wild cotton-bolls in Arizona.

BETHYLIDAE.

Holepyris hawaiiensis, Ashmd.

Bridwell (1920*a*) found that in captivity this wasp will attack various Lepidopterous larvae, including those of *Plodia interpunctella,* Hb., and *Corcyra cephalonica,* Staint. One egg was laid on each larva. The wasp is abundant in Hawaii in places where food is stored. Munro and Thomson (1929) and Richards and Herford (1930) record the association of this wasp with the larvae of *E. elutella* and *C. cephalonica* in cacao warehouses in England, where, however, it cannot yet be regarded as established.

Perisierola emigrata, Rohwer.

Bridwell (1919) bred this wasp experimentally on the larvae of *E. elutella.*

Perisierola gallicola, Kieff.

Kieffer, in describing this species (1905, pp. 237, 261), records that it was bred in Italy from the galls of *Cynips coriaria*, Hainh., *C. lignicola*, Htg., and *Aphelonyx cerricola*, Gir. In (1914) he adds (quoting Silvestri, 1912, pp. 284–5) that it has also been bred from *Ceratonia* beans attacked by the larvae of *Myelois ceratoniae*, Z., *E. elutella*, *Cryptoblabes gnidiella*, Mill., and *Borkhausenia.* Possibly in the galls, too, it was really attacking Lepidopterous larvae.

DIPTERA : TACHINIDAE.

Epigrymyia (Drepanoglossa) floridensis, Tns.

Record by Hamlin, Reed and Phillips (1931) as an occasional parasite of *Plodia interpunctella*, Hb., in California.

PREDATORS.

HYMENOPTERA.

Myers (1928, 1929) records that in Australia the two ants, *Iridomyrmex detectus*, Sm., and *I. rufoniger*, Lowne, are sometimes quite important enemies of *Plodia* and to a less extent of *Ephestia cautella*, whose larvae they carry off from sheds where the fruit is stacked. Sometimes the adult moths are also attacked.

COLEOPTERA.

Gnathocerus cornutus, F.

Johnson (1895*b*) recorded that this beetle will eat *E. kühniella* larvae, and Morison (1925) found that it finds its optimum conditions in flour already contaminated by other insects, especially *E. kühniella.* It appears to require a certain admixture of animal food and is capable of eating large numbers of the eggs and pupae of the moth.

Tribolium confusum, Duv., and **T. castaneum** Herbst **(ferrugineum).**

Recorded by Johnson (1895*b*) as preying on the larvae and especially the pupae of *E. kühniella.* In one experiment, 100 *T. confusum* destroyed two-thirds of a culture of some hundreds of recently spun up larvae, from which, eventually, only two moths emerged.

Tenebroides mauretanicus, L.

Johnson (1895*b*) records this beetle as an enemy of *E. kühniella.*

HEMIPTERA.

Bridwell (1920*b*) notes that he found a small predacious bug preying on the larvae of *Plodia interpunctella.* This may perhaps have been *Piezostethus flavipes,* Reut., which Richards and Herford (1930) record as associating with the larvae of *E. elutella* in cacao. The bug has also been recorded from grain.

ACARINA.

Pediculoides ventricosus, Newp.

Chittenden (1911) and Candura (1928) record this mite as attacking the early stages of *E. cautella* and *E. kühniella* respectively. Tosi (1929) found it a serious enemy of *Plodia interpunctella.* Herfs (1925), however, found that *E. kühniella* was not nearly so susceptible as various other moth and beetle larvae.

Seiulus muricatus, Koch.

Burkhardt (1919) found this mite eating the eggs of *E. kühniella.* It is highly probable that several other species are involved in the epidemics which sometimes destroy *Ephestia* cultures. *Cheyletes eruditus,* Schrk., normally an enemy of other mites, is certainly sometimes implicated.

MAMMALIA.

Mus musculus, L.

Johnson (1895*b*) records that a house mouse ate 254 pupae of *E. kühniella* in one night. We have also found mice a serious nuisance under laboratory conditions.

MICROORGANISMS.

PROTOZOA.

Thelohania ephestiae, Mattes.

Mattes (1928) has worked out the life-history of this Microsporidian parasite of the larvae of *E. kühniella,* to which it is sometimes very pathogenic. Infection may be due to the attacks of parasitic Hymenoptera, but this has not been satisfactorily elucidated as yet. The parasite multiplies exceedingly in the fat-body of the larva. White (1927) and Kühn and Henke (1929) further mention an unidentified Sporozoan parasite. According to White it gains entrance with the food, passes through the gut-wall, enters the fat-bodies and here becomes very abundant. Death often ensues, either in the larval, pupal or adult stage of the host, and the disease is very infectious. Kühn and Henke show that infection by a Sporozoan often leads to a great development of the white scales on the wings of *E. kühniella.* Mattes (1927) further records a non-pathogenic organism living in the gut of the larvae of *E. kühniella,* viz. *Micrococcus ephestiae,* Mattes. Finally he found a new species of Schizogregarine which lives in the fat-body of the same larva and which he thinks may be transmitted by parasitic Hymenoptera.

BACTERIA.

Bacillus thuringiensis, Berl.

Berliner (1915) described this organism (first recorded by Berliner, 1911) as the cause of " wilting " in the larvae on *E. kühniella.* Infection occurs when the larvae eat the spores which are always fatal unless taken shortly before moulting or about two days before pupation. It is apparently specific to *E. kühniella*; at any rate it was not transmissible to various Coleopterous larvae. White (1927) found the same parasite in *E. kühniella* larvae in U.S.A.

He found that the host usually died in the larval stage, the dead body blackening and becoming brittle when dry. Mortality was greatest in the summer, when it might be as high as 100 per cent. Mattes (1927) found that the web spun by the larvae is sufficient to protect them from infection when flour containing the spores is dusted over them. *B. thuringiensis* has recently been studied in great detail in connection with its use for controlling the Corn-borer, *Pyrausta nubilalis*, Hb., see Chorine (1929), Metalnikov and Chorine (1929, *a* and *b*). Metalnikov and Chorine (1929*b*) found that though very virulent to a variety of Lepidopterous larvae, it did not effect those of other orders.

Bacillus agilis, Mattes.

Mattes (1927) describes this parasite, which is also pathogenic under favourable conditions and enters through the mouth of the larva. Mixed infections of the two species of *Bacillus* are not uncommon. Bacterial epidemics amongst species of *Ephestia* and *Plodia* are not uncommon in the autumn in London warehouses.

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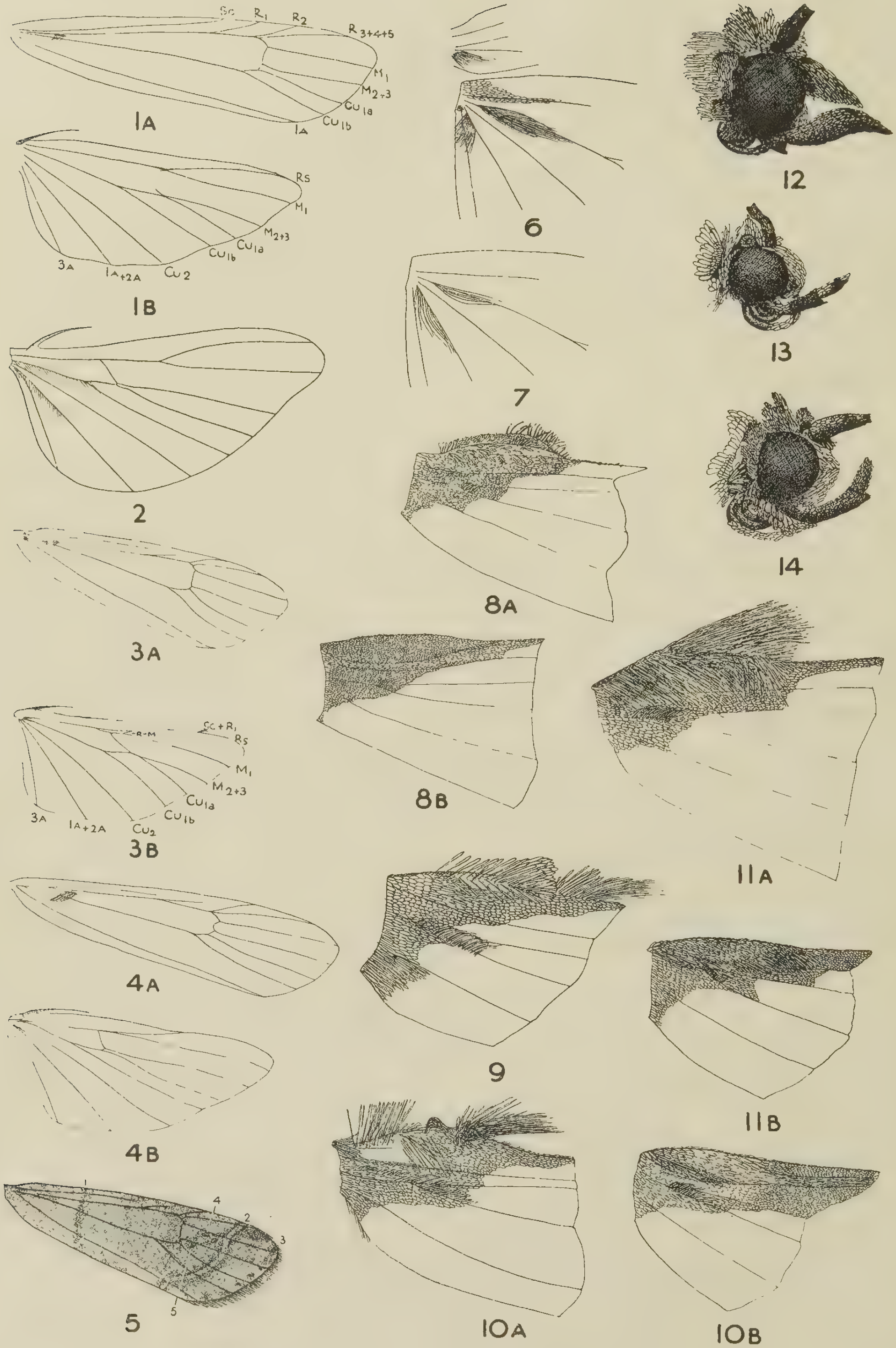
Plate V.


Sc
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4A
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8A
8B
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10A
10B
11A
11B
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Details of species of *Plodia* and *Ephestia*.

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EXPLANATION OF PLATES V–XII.

PLATE V.

Fig. 1. (*a*) Forewing, (*b*) hindwing of *Plodia interpunctella*, Hb.
2. Hindwing of *Ephestia rubrimediella*, Hmpsn.
3. (*a*) Forewing, (*b*) hindwing of *E. elutella*, Hb.
4. (*a*) Forewing, (*b*) hindwing of *E. figulilella*, Gregs.
5. Forewing of a well-marked specimen of *E. elutella*, Hb. (1) First line. (2) Second line. (3) Third line. (4) Orbicular stigma. (5) Claviform stigma.
6. Dorsal view of base of fore- and hindwings of *E. elutella*, Hb. ♂, to show the modified scales.
7. Base of hindwings of *E. elutella*, Hb. ♀, to show the cubital and anal pecten.
8. Ventral view of the base of the forewings of *E. elutella*, Hb. ♂, to show the costal fold (*a*) expanded, (*b*) not expanded.
9. The same of *E. micaceella*, Rag. ♂, expanded.
10. The same of *E. figulilella*, Gregs. ♂, (*a*) expanded, (*b*) not expanded.
11. The same of *E. cautella*, Wlk. ♂, (*a*) expanded, (*b*) not expanded.
12. The head of *Plodia interpunctella*, Hb., seen from the right side, only the base of the antennae shown.
13. The same of *Ephestia* (*Strymax*) *dorae*, Dyar.
14. The same of *E. elutella*, Hb.

PLATE VI.

Fig. 15. Ventral view of genitalia of *E. elutella*, Hb. ♂.
16. Ventral view of gnathos and struts and dorsal thickenings of the anellus of *E. moebiusi*, Rebel ♂.
17. The same of *E. disparella*, Rag. ♂.
18. The same of *E. mistralella*, Mill. ♂.

FIG. 19. The same of *E. parasitella*, Staud. ♂, right side only shown.
20. Ventral view of right dorsal thickening of the anellus of *E. woodiella*, sp. n. ♂.
21. Ventral view of genitalia of *E. cautella*, Wlk. ♂.
22. The same of *E. figulilella*, Gregs. ♂.
23. The same of *E. calidella*, Gn. ♂.
24. The same of *E. afflatella*, Mn. ♂.
25. Ventral view of the reflexed part of the valve and dorsal thickening of the anellus in a varietal form of *E. afflatella*, Mn. ♂ (Syria).
26. Ventral view of genitalia of *E. abstersella*, Z. ♂.

In all the figures of the complete genitalia, the valve is shown in strong lines on the left hand side (right side of insect) and in dotted lines on the right, in order to reveal the structures lying under it. The aedeagus is omitted. All the drawings on Plate VI are to the same scale (× c. 30).

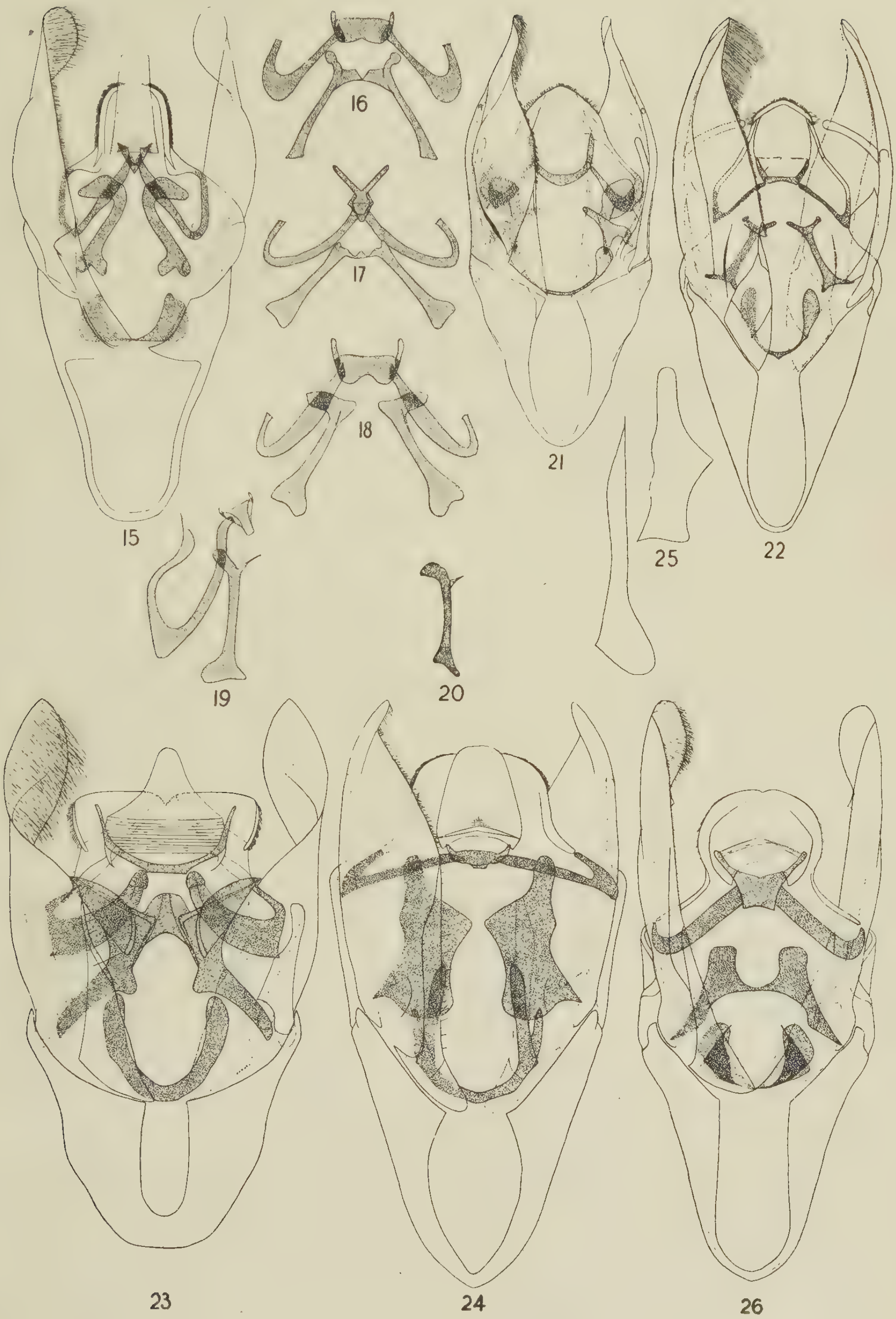
PLATE VII.

FIG. 27. Ventral view of genitalia of *E. kühniella*, Z. ♂.
28. The same of *E. rubrimediella*, Hmpsn. ♂.
29. The same of *E. welseriella*, Z. ♂.
30. The same of *E. (Strymax) dorae*, Dyar ♂.
31. Ventral view of gnathos and subscaphium of *E.* (*S.*) *bipunctella*, Hmpsn. ♂.
32. Ventral view of genitalia of *Plodia interpunctella*, Hb. ♂.
33. The same of *Ephestia rileyella*, Rag. ♂.
34. The same of *E.* (*Strymax*) *albidiorella*, sp. n. ♂.
35. The thickening in the vesica of *E.* (*S.*) *albidiorella*, sp. n. ♂.
36. Ventral view of genitalia of *E. colorella*, Dyar ♂.

In all the figures of the complete genitalia, the valve is shown in strong lines on the left hand side (right side of insect) and in dotted lines on the right, in order to reveal the structures lying under it. The aedeagus is omitted. All the drawings are to the same scale (× c. 30), except fig. 35 (× c. 15).

PLATE VIII.

FIG. 37. Eighth segment and modified scale-tufts of *Ephestia welseriella*, Z. ♂. (Diagrammatic.)
38. The same of *E. kühniella*, Z. ♂.
39. The same of *E. cautella*, Wlk. ♂.
40. The same of *E. elutella*, Hb. ♂.
41. The same of *E. moebiusi*, Rebel ♂.
42. The same of *E. rileyella*, Rag. ♂.
43. The same of *E. colorella*, Dyar ♂.
44. The same of *Plodia interpunctella*, Hb. ♂.
45. The same of *P. dolorosa*, Dyar ♂.
46. The right valve of genitalia of *Ephestia kühniella*, Z. ♂, seen from the side.
47. Aedeagus of *E. kühniella*, Z. ♂, seen from the right.
48. The right valve of genitalia of *E. rubrimediella*, Hmpsn. ♂, seen from the side.
49. Aedeagus of *E. rubrimediella*, Hmpsn. ♂, seen from the right.
50. The same of *E. cautella*, Wlk. ♂.
51. The right valve of genitalia of *E. cautella*, Wlk. ♂, seen from the side.
52. Aedeagus of *E. figulilella*, Gregs. ♂, seen from the right.
53. The right valve of genitalia of *E. figulilella*, Gregs. ♂, seen from the side.
54. The same of *E. elutella*, Hb. ♂.
55. Aedeagus of *E. elutella*, Hb. ♂, seen from the right.
56. The same of *E. mistralella*, Mill. ♂.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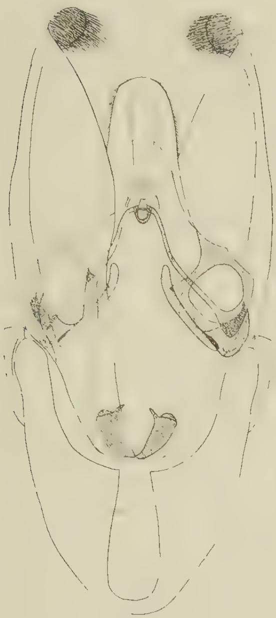
Details of species of ***Ephestia.***



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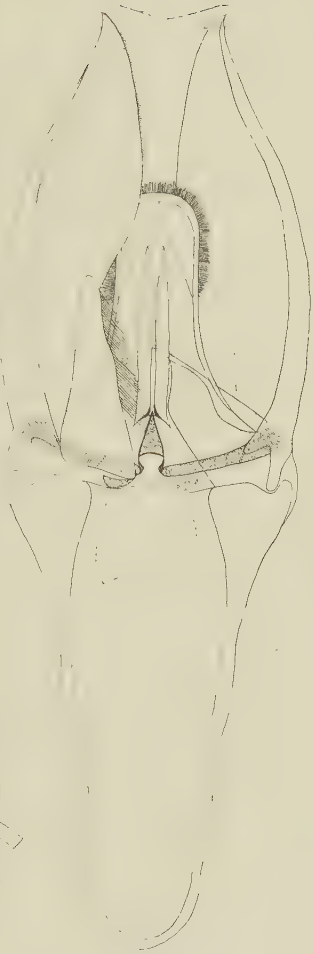

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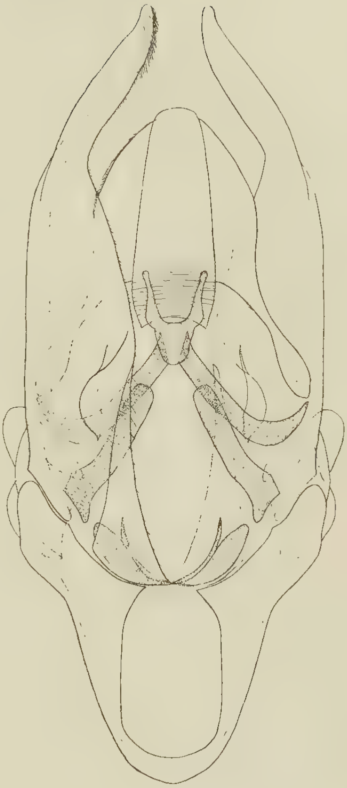

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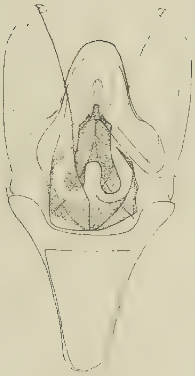

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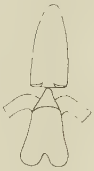

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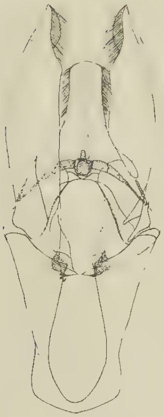

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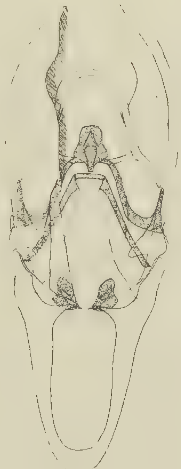

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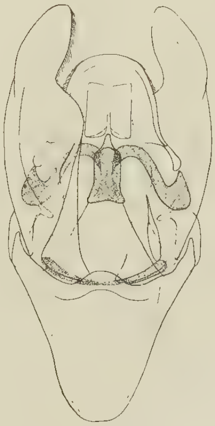

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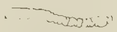

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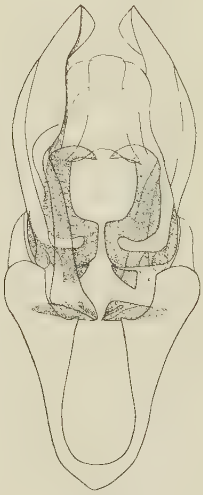

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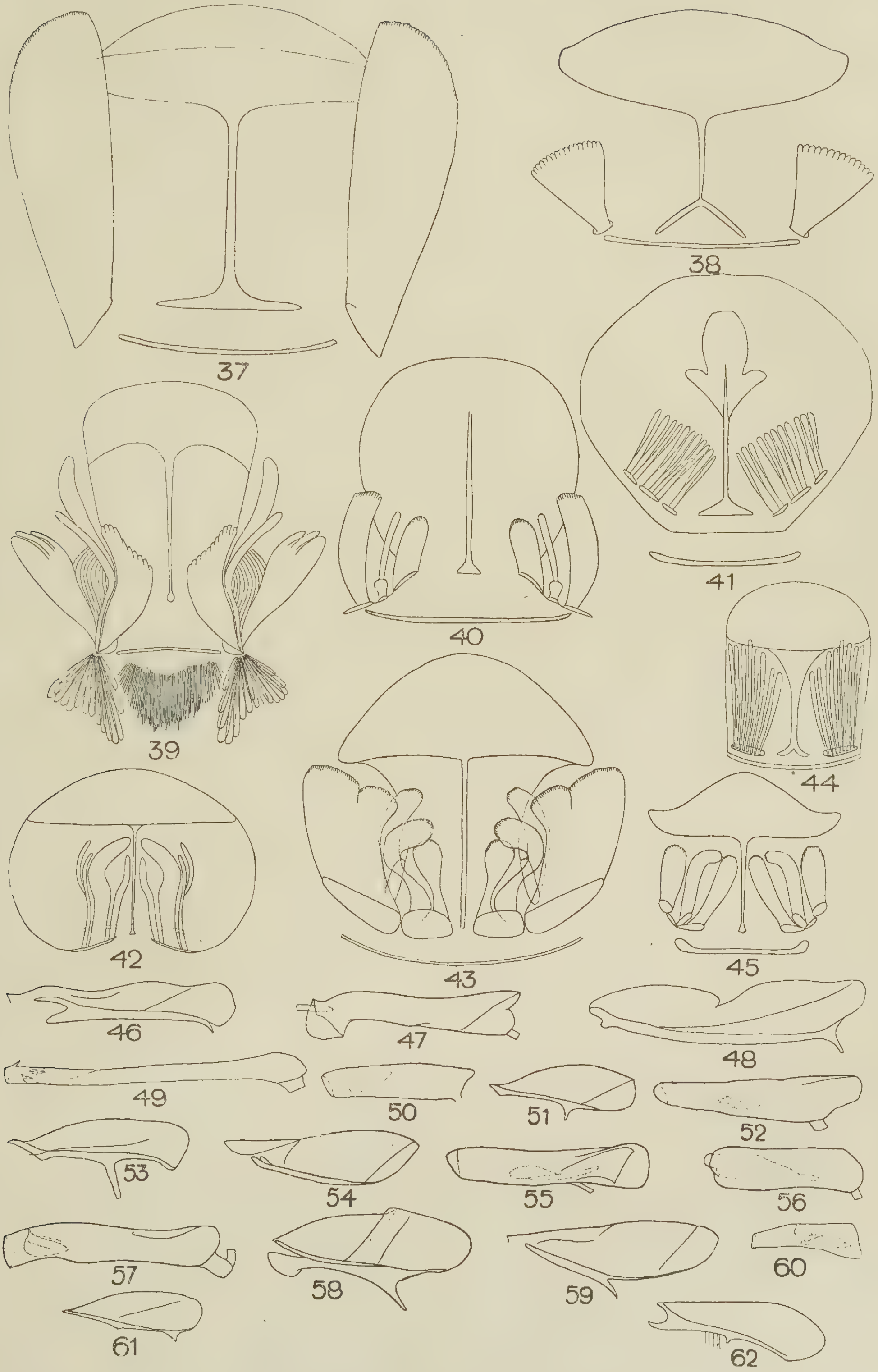
Details of species of *Ephestia*.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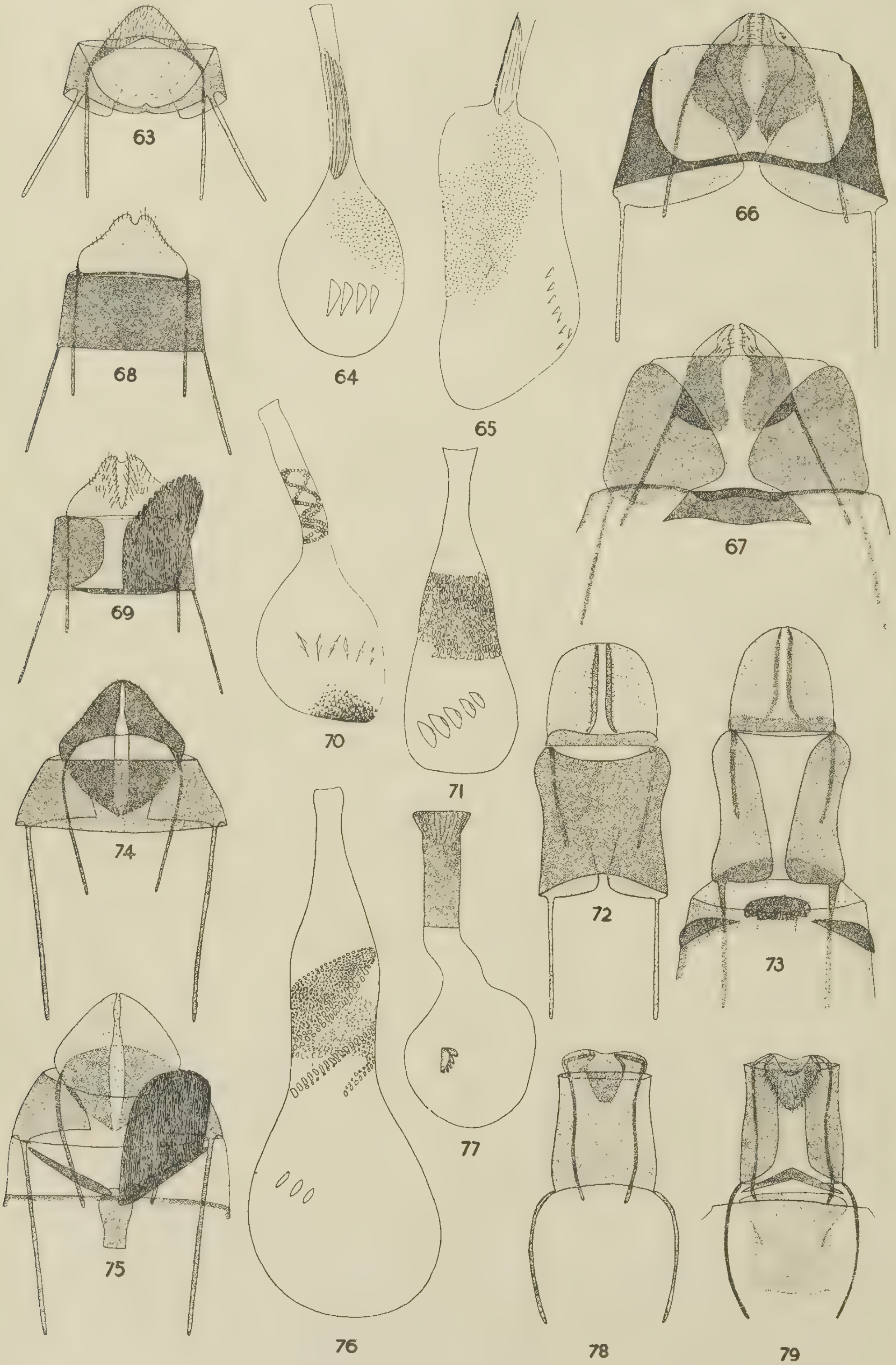
Details of species of ***Plodia*** **and** ***Ephestia.***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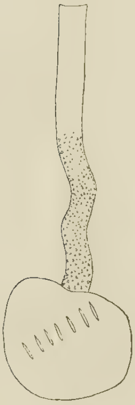
Details of species of *Ephestia.*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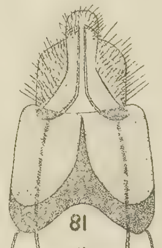
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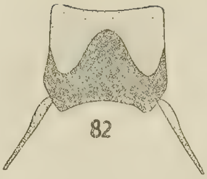
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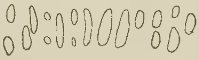
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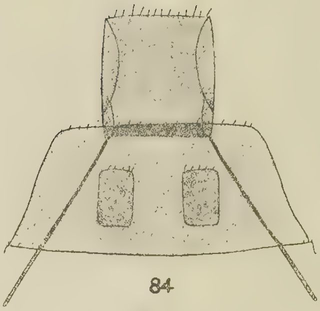
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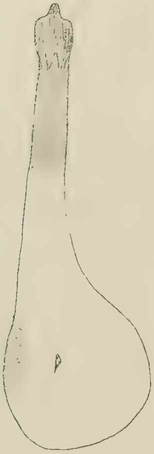
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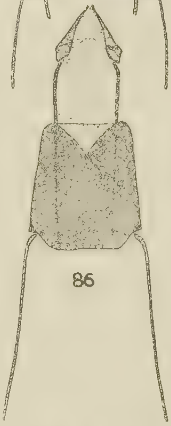
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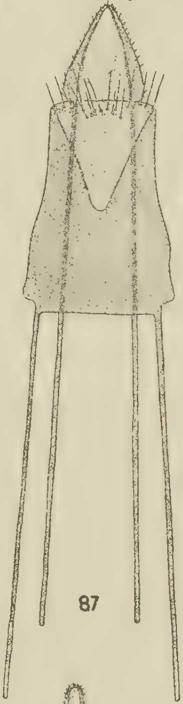
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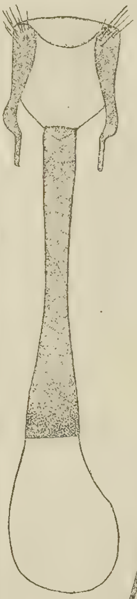
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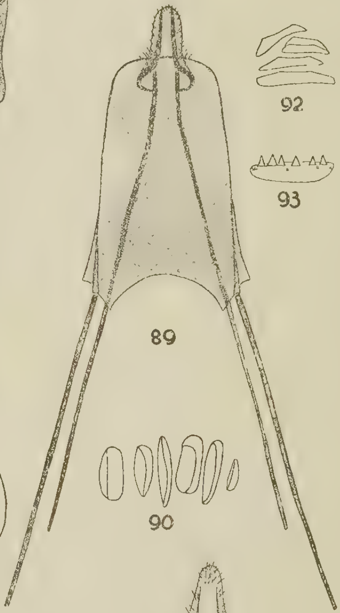
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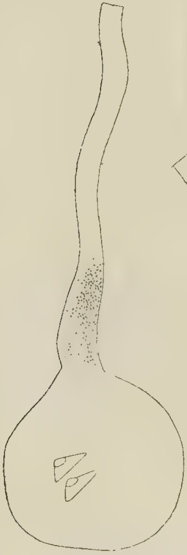
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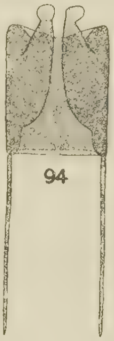
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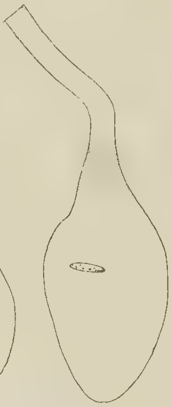
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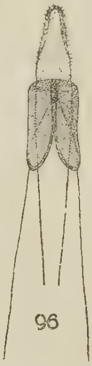
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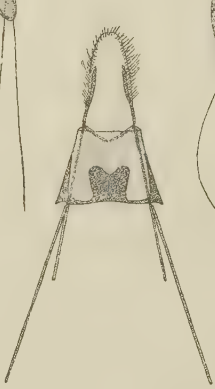
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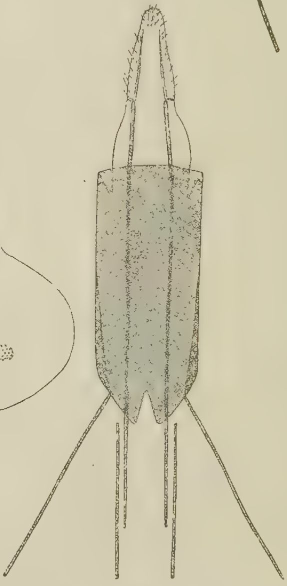
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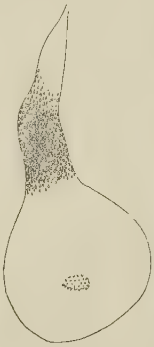
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Details of species of *Ephestia*.

Fig. 57. The same of *E. calidella*, Gn. ♂.
58. The right valve of genitalia of *E. calidella*, Gn. ♂, seen from the side.
59. The same of *E. woodiella*, sp. n. ♂.
60. Aedeagus of *Plodia interpunctella*, Hb. ♂, seen from the right.
61. The right valve of genitalia of *Plodia interpunctella*, Hb. ♂, seen from the side.
62. The same of *P. dolorosa*, Dyar ♂.

Figures 37–45 are × c. 30; figures 46–61 × c. 15.

Plate IX.

Fig. 63. Eighth tergite and ovipositor of *E. cautella*, Wlk. ♀.
64. Bursa copulatrix of *E. cautella*, Wlk. ♀.
65. The same of *E. calidella*, Gn. ♀.
66. Eighth tergite and ovipositor of *E. calidella*, Gn. ♀.
67. Seventh and eighth sternites of *E. calidella*, Gn. ♀.
68. Eighth tergite and ovipositor of *E. figulilella*, Gregs. ♀.
69. Eighth sternite of *E. figulilella*, Gregs. ♀. (Left scale-tuft removed.)
70. Bursa copulatrix of *E. figulilella*, Gregs. ♀.
71. The same of *E. disputella*, sp. n. ♀.
72. Eighth tergite and ovipositor of *E. disputella*, sp. n. ♀.
73. Seventh and eighth sternites of *E. disputella*, sp. n. ♀.
74. Eighth tergite and ovipositor of *E. afflatella*, Mn. ♀.
75. Seventh and eighth sternites of *E. afflatella*, Mn. ♀. (Left scale-tuft removed.)
76. Bursa copulatrix of *E. afflatella*, Mn. ♀.
77. The same of *E. colorella*, Dyar ♀.
78. Eighth tergite and ovipositor of *E. colorella*, Dyar ♀.
79. Seventh and eighth sternites of *E. colorella*, Dyar ♀.

The figures of the sternites and tergites are × c. 30, of the bursa copulatrix × c. 15.

Plate X.

Fig. 80. Bursa copulatrix of *E. elutella*, Hb. ♀.
81. Eighth tergite and ovipositor of *E. elutella*, Hb. ♀.
82. Eighth tergite of *E. woodiella*, sp. n. ♀.
83. Chitinised plates in the walls of the bursa of *E. moebiusi*, Rebel ♀.
84. Seventh and eighth sternites of *E. parasitella*, Staud. ♀.
85. Bursa copulatrix of *E. rileyella*, Rag. ♀.
86. Eighth tergite and ovipositor of *E. rileyella*, Rag. ♀.
87. The same of *E. rubrimediella*, Hmpsn. ♀.
88. Eighth sternite and bursa copulatrix of *E. rubrimediella*, Hmpsn. ♀.
89. Eighth tergite and ovipositor of *E. tephrinella*, Led. ♀.
90. Chitinised plates in the walls of the bursa of *E. tephrinella*, Led. ♀.
91. Bursa copulatrix of *E. kühniella*, Z. ♀.
92. Chitinised plates in the walls of the bursa of another specimen of *E. kühniella*, Z. ♀.
93. Eighth tergite and ovipositor of *E. scotella*, Hmpsn. ♀.
94. Eighth sternite of *E. dowsoniella*, sp. n. ♀.
95. Bursa copulatrix of *E. scotella*, Hmpsn. ♀.
96. Eighth tergite and ovipositor of *E. vapidella*, Mn. ♀.
97. The same of *E. scotella*, Hmpsn. ♀.
98. Lamina dentata of *E. kühniella*, Z. ♀.
99. Bursa copulatrix of *E. vapidella*, Mn. ♀.

The figures of the sternites and tergites are × c. 30, of the bursa and copulatrix, chitinised plates and lamina dentata × c. 15.

PLATE XI.

FIG. 100. Eighth tergite and ovipositor of *E. calonella*, Rag. ♀.
101. Lamina dentata of *E. calonella*, Rag. ♀.
102. Eighth tergite and ovipositor of *E. welseriella*, Z. ♀.
103. Bursa copulatrix of *E. welseriella*, Z. ♀.
104. Eighth tergite and ovipositor of *E.* (*Strymax*) *pyllis*, Dyar ♀.
105. Bursa copulatrix of *E.* (*S.*) *pyllis*, Dyar ♀.
106. The same of *E. declivella*, Z. ♀.
107. Eighth tergite and ovipositor of *E. declivella*, Z. ♀.
108. Bursa copulatrix of *E.* (*Strymax*) *latercula*, Z. ♀.
109. Eighth tergite and ovipositor of *E.* (*S.*) *latercula*, Z. ♀.
110. The same of *E.* (*S.*) *bipunctella*, Hmpsn. ♀.
111. Bursa copulatrix of *E.* (*S.*) *bipunctella*, Hmpsn. ♀.
112. Eighth tergite and ovipositor of *Plodia interpunctella*, Hb. ♀.
113. Bursa copulatrix of *P. interpunctella*, Hb. ♀.
114. The same of *P. dolorosa*, Dyar ♀.

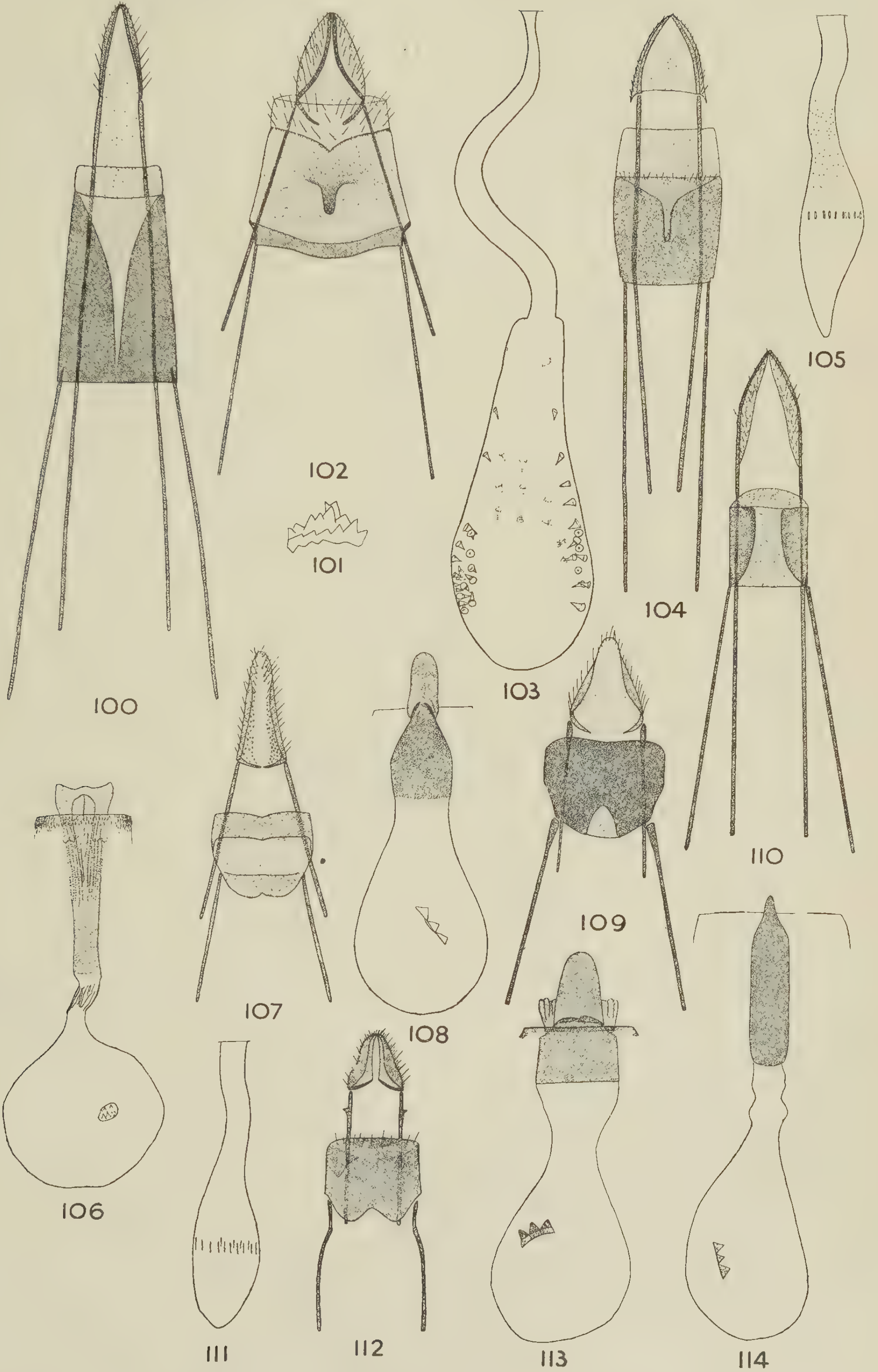
The figures of tergites and ovipositors are × c. 30, those of the bursa copulatrix and lamina dentata are × c. 15.

PLATE XII.

Larval structures.

FIG. 115. Antenna of *Plodia interpunctella*, Hb.
116. The same of *E. calidella*, Gn.
117. The left mandible of *E. elutella*, Hb.
118. Dorsal view of the labrum of *Plodia interpunctella*, Hb.
119. Ventral view of labium and maxillae of *E. elutella*, Hb. (1) The basal ring of labium.
120. The same, left maxilla more magnified.
121. The same, labial palp.
122. Ventral view of left half of labium and maxilla of *Plodia interpunctella*, Hb.
123. Dorsal view of head of *E. kühniella*, Z.
124. The same, lateral ventral view.
125. Lateral view of thorax and first abdominal segment of *E. kühniella*, Z. (six following segments similar).
126. Lateral view of abdominal segments 8–10 of *E. kühniella*, Z.
127. Ventral view of thorax and abdominal segments 1–3 of *E. kühniella*, Z.
128. Ventral view of abdominal segments 7–10 of *E. kühniella*, Z.
129. Ventral view of pupa of *E. elutella*, Hb., male. (1) Fore-leg ; (2) Wing ; (3) Antenna ; (4) 3rd pair of legs ; (5) 8th sternite ; (6) 9th sternite.
130. Ventral view of caudal segments of pupa of *E. elutella*, Hb., female. (1) 8th sternite ; (2) 9th sternite.

In the figures of the larval abdomen and thorax, Greek letters refer to Fracker's system of larval classification. Figures 115–20 and 122 were prepared by R. L. Williams, technical assistant in the laboratory.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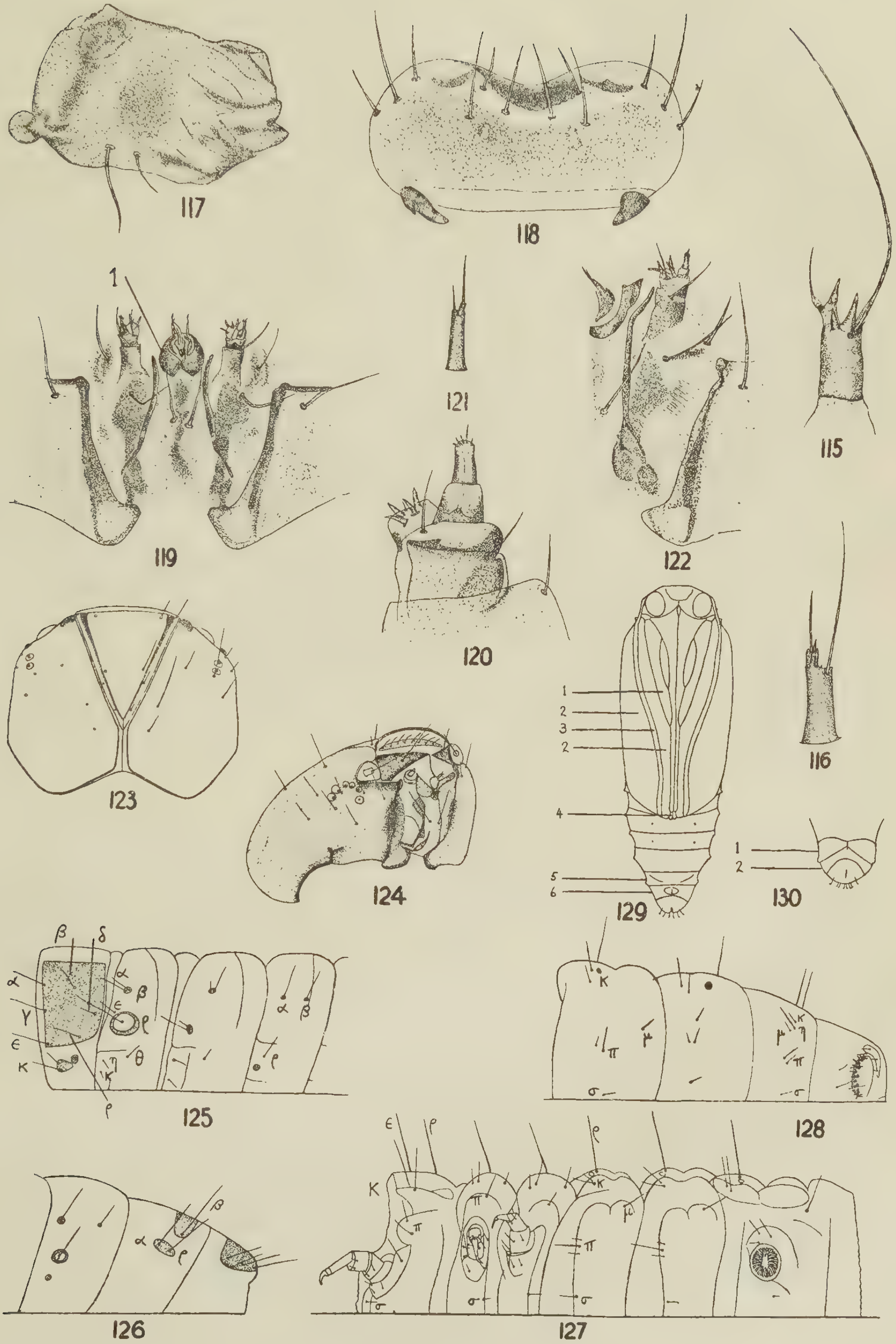
Details of species of *Plodia* **and** *Ephestia.*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Details of species of *Plodia* and *Ephestia*.

THE FORMS OF *ACRAEA JOHNSTONI*, GODM. (LEP. NYMPHALIDAE), AND THEIR DISTRIBUTION

By G. D. Hale Carpenter, M.B.E., D.M., F.L.S., F.Z.S.

[Read 1st June, 1932.]

Plates XIII, XIV.

This paper is the result of a suggestion by Prof. E. B. Poulton, F.R.S., that the mimetic form *butleri*, Auriv., of *Acraea johnstoni*, Godm., is probably a true geographical race. In order to establish this, it seemed advisable to take notes on all the available material of this species, and the results now presented are taken from a total of 1668 specimens. I have examined every example in the Hope Department of the Oxford University Museum where this work has been done, as well as in the National Collection and at Tring. Reports, in reponse to requests for information, have kindly been sent on the collections at Witley; Nairobi and Kitale in Kenya Colony; Berlin; Stockholm; and on several private collections. To all those who have so generously helped in the collection of these data my thanks are expressed below.

Much kind help has been received from Prof. Poulton, F.R.S., in elucidating the points brought out in this paper. Most grateful thanks are here expressed to Mr. F. J. Griffin, Registrar of the Entomological Society, and Dr. R. Hanitsch of the Hope Department, for help in obtaining and translating references; to Mr. N. D. Riley and Dr. Karl Jordan for assistance in examining specimens; and, especially, to the following gentlemen for sending detailed reports on collections which I could not examine myself: Dr. C. le Doux, Dr. A. Roman, Mr. G. Talbot, Dr. V. G. L. Van Someren, Capt. H. F. Stoneham, and Major F. Moysey.

Bibliography.

The species was first described by Godman in 1885 (1) from a Kilimanjaro specimen of what is now known as the form *johnstoni*. Butler, in 1888 (2), described the first female of the form now known as *confusa* as the female of *johnstoni* and noted its resemblance to *Amauris hanningtoni*. In 1891 Rogenhofer (3, 4) described Butler's female as a new species, *Planema confusa*, mentioning both sexes, and also described as *telekiana* a dark form of *johnstoni*. Oberthür in 1893 (5) gave names to a number of forms under the specific name of *proteina*, and he was the first to recognise the peculiarly characteristic indentation of the black margin of the hind-wing by the central pale area.

Holland dealt with synonymy in 1893 (6), and Trimen in 1894 (7) made a remark which is worth quoting as of historical interest. "The resemblance borne by the female *confusa* to *Amauris echeria* (var. *albimaculata*, Butler) is very strong, but I hesitate to adopt Mr. Butler's conclusion that the former is evidently modified in imitation of the *Amauris*, because, firstly, both *Amauris* and *Planema* are equally protected genera and extensively mimicked by butterflies of other groups, and secondly, *P. johnstoni* female does not either in pattern or colouring diverge much from its congeners, coming near *P. lycoa*, Fabr." The interest of this paragraph lies in the fact that Trimen, who had in 1869 recognised in the S. African fauna the phenomena described as mimicry by Bates in 1862, had not perceived the principle of synaposematic resemblance announced by Müller in 1879.

Karsch in 1894 described the form *octobalia* (8), and in 1895 Butler described as a variety of *lycoa* (9) the form now known as *butleri*, which is the central point of this paper. In 1896 (10) he dealt with the series of names devised by Oberthür. The species was dealt with as of bionomic interest by Poulton in 1897 (11), who showed that several forms are synaposematic with Danaines and other Acraeines.

Aurivillius in 1898 (12) labelled the species *johnstoni* for the first time, and grouped other named " species " as forms of *johnstoni*, except Butler's female variety of *lycoa*. The male of this was described by Grose-Smith in 1900 (13) under the name of *toruna*; the female was also described.

Poulton, in another bionomic article in 1906 (15), considered the probable order of evolution, in time, of the various forms, and dealt with their models. A tabular statement of the proportionate numbers of various forms was given by St. Aubyn Rogers in 1908 (16), and Heron (17) recorded additional specimens of *toruna* in 1909.

The confusion between *lycoa* and *johnstoni* was cleared up by Eltringham in 1910 (18), and a more complete account given by him in 1911 (19). He pointed out that *toruna* is a geographical race of *johnstoni* and not a separate species. The subject was again dealt with in his monograph in 1912 (20).

In 1913 Richelmann (21) described as a new species, *Acraea silvicola*, a female specimen which still remains unique, coming from Usambara. It is a form of *johnstoni*, and as the original description is not generally accessible, and the specimen is of such great interest, the description is here quoted in full.

> " *Acraea silvicola.* Im Usambara erlangte ich im Schumewald, etwa 2000 m. hoch, eine Acraea, die von andern Arten wesentlich abweicht. Am nächsten scheint sie mir *A. johnstoni* Godm. zu stehen, doch sind bei ganz anderer Zeichnungsanlage die Vorderflügel kürzer (Vorderrand 23 mm., Hinterrand 18 mm.), die Vorderspitze abgerundeter und der Aussenrand gerade ohne die geringste Ausbuchtung. Oberseite Vorderflügel: Kastanienbraun, an der Wurzel etwas schwarz. Flügelspitze von der Mittelzelle ab breit schwarz, auch der Aussenrand (Feld 1a und 1b) ist schwarz. Die Rippen 1 und 2, sowie diejenigen um die Mittelzelle sind lebhaft schwarz, so dass die braune Grundfarbe fast in Flecke getrennt erscheint. In der breit schwarzen Flügelspitze stehen 2 weisse Flecke der eine in der Mitte des Felder 4, der andere in den Feldern 5, 6, und 7.
>
> " Hinterflügel: Wurzel schwarz bis ungefähr zu $\frac{1}{3}$ der Mittelzelle dann folgt der ausgedehnte kastanienbraune Teil ohne Zeichnungen, den ein schwarzer Aussenrand von $2\frac{1}{2}$–$3\frac{1}{2}$ mm. Breite begrenzt. Die kurzen Striche auf den Zwischenaderfalten treten kaum hervor. *Unterseite.* Vorderflügel Wurzel nicht verdunkelt die braune Farbe von derselben Ausdehnung wie oben, durch die breit schwarzen Rippen geteilt.
>
> " Zwischen dem Ende der Mittelzelle und den Weissen Flecken der Vorderspitze liegt eine schwarze Querbinde. Der übrige Spitzenteil und Aussenrand ist grau mit Zwischenaderstrichen. Hinterflügel: Wurzel bräunlich mit 11 Wurzelpunkten: davon zwei im Felde 1a, einer im Felde 1b, drei im Felde 2, zwei in der Mittelzelle, zwei in Felde 8, einer im Felde 9. In der Flügelmitte eine unregelmassig begrenzte helle Mittelbande vom Vorderrande bis zur Rippe 3, der Aussenrand 8 mm. breit, bräunlichgrau mit Zwischenaderstrichen. Das im Juli erbeutete Stück ist ein ♀."

An account of a small family bred from a known female was given by Eltringham in 1915 (22). A paper on the Acraeas of S. Rhodesia by O'Neil in

1918 (23) referred to the relative edibility of this species to birds, a subject on which more information is given in Swynnerton's memoir of 1919 (24), a summary of the results being given on the last two pages.

The form *butleri* was considered by Aurivillius in 1925 (25) not to belong to *johnstoni*, in spite of Eltringham's monograph. Records of bred families form the subject of a memoir by Poulton in 1926 (26) in which he showed that Mendelian relationship exists, and drew attention to inheritance of a very small variation; another bred family is described in the next reference (27).

A short account of the species in Kenya and Uganda, with descriptions of the early stages, was given by Van Someren and Rogers in 1926 (28). Joicey and Talbot in 1927 (29) described a rare form which answers Aurivillius' objection to including *butleri* under *johnstoni*, and as it is of importance and not very accessible, the description is here quoted.

> " *Acraea johnstoni*, Godm. ♀ f. *praelongata*.
>
> " A form similar to *semialbescens*, Ob. Fore-wing with white spots, the subapical ones larger than in other forms, the spot in 5 projecting more distad than in other forms, the outer lower edge touching the inner upper edge of the spot in 4; spot in 2 forming an oblong patch which narrows proximally and nearly reaches the cell; in other forms the spot in 2 is close to the cell, but here it is extended distad and touches the tornal spot; tornal spot large and rounded. Some rufous scaling in cellules 3–6 between the subapical band and the spot in 2. Hind-wing with the band pale ochreous, its edges not sharply defined; basal black more extended than in other forms, reaching to vein 7 and posteriorly to more than midway between base and vein 2.
>
> " Underside of hind-wing with more extended red-brown basal area.
>
> " Length of fore-wing: 36 mm.
>
> " Hab.—S.E. Congo: S. Lufonso River, Lake Mweru District, 5000 feet, March 1922, wet season, *T. A. Barns*, 1 ♀."

The forms of *johnstoni* in S.E. Sudan were described by the writer in 1928 (30), and allusion was made to its form in Abyssinia. A brief note on its edibility to a mantis was published by Poulton in 1930 (31).

THE FORMS OF *A. JOHNSTONI.*

It now remains to consider in turn each of the forms, using the order given by Eltringham (20).

Form *johnstoni*, Godm. (Pl. XIII, figs. 1 & 2).

This has the fore-wings tawny orange with more or less black at the base, and the four characteristic spots of the species paler or nearly white. Apex and margin black. Hind-wing white with broad black margin.

The pattern is very unstable, and it is hard to put two similar specimens together. The figures show a male and female corresponding to the original description (1), with no black suffusion at the base of the fore-wing. It is more common for this to be present in varying degree, leading up to such a form as is shown in Pl. XIII, fig. 6. The hind-wing pale area may be white or yellowish, or all stages in between, or streaked with brown, and a form may thus be produced such as fig. 6, which seems to correspond to Rogenhofer's " *telekiana* " (4). This also leads to *confusa*, and every grade of transition can be found until the last stage is shown by the specimens to which Poulton alludes (26) as evidence of inheritance of minute variations.

It is sometimes difficult to decide whether a specimen is *johnstoni* or *fulvescens*. It is curious that *johnstoni* should have been the first form to give the name to the species, for it is not the commonest; the table on p. 259 shows that it comes third in order of frequency, the group of *confusa* + *flavescens* + *valdemaculosa* taking first place, and *fulvescens* the second. (For the purposes of the table the form names were interpreted as broadly as possible, and only those were classed as "transitional" varieties which could hardly be given a name.) It is possible that *confusa*, the commonest, had been mistaken at first for *lycoa* which had long been known, and that *johnstoni* attracted more attention.

Form *confusa*, Rogenh. (Pl. XIV, fig. 7).

Under this head are included the specimens with small white spots on very dark brownish-black fore-wings, and the basal patch of the hind-wing whitish or yellowish. In the fore-wings of a number of specimens from the Dabida Hills (area 4) and sometimes from elsewhere there is a tendency for the posterior angle of the most anterior spot to enlarge outwards and backwards to meet the spot in area 4 of the wing.

This is an important aid in producing likeness to the white-spotted *Amauris* which (*vide infra*) are predominant in the eastern area and have a pair of closely apposed white spots in the same relative position (see Pl. XIV, fig. 8). But this variation has another significance, for it is the first step towards the very much enlarged spots which lead through the ♂ *butleri* to their amalgamation to form the band of ♀ *butleri* (see Pl. XIII, figs. 9, 10, 11). A rare variation is shown in Pl. XIV, fig. 10; this is of great importance because it exemplifies the origin of a pale patch in area 3 of the fore-wing which serves to connect the two separate pairs of spots, and shows how the complete ♀ *butleri* band has been formed from isolated spots.

Two specimens in a collection made by myself on Mt. Elgon are of much interest because of the colour of the fore-wings. This from the base as far out as the spots, is of a blackish-brown, seen under the microscope to be due to admixture of black with brown scales. The general effect is somewhat similar to the peculiar purplish-brown hue of the base of the wings of *butleri* and *Planema quadricolor*, and seems to be the nearest approach to that hue that can be produced by the eastern specimens of *johnstoni*. But it has not been intensified into a likeness to *quadricolor*; moreover the pattern is of the characteristic four-spotted type of *confusa*, and though the spots are tawny and not white they are quite small. The specimens are obviously a mixture of *confusa* and *johnstoni*, and at first I was inclined to think that they showed how *butleri* might have arisen from *confusa*. But such specimens as those shown in Pl. XIV, fig. 10, supply a much more convincing path for the transformation to have taken; indeed it is only these that have the peculiar purplish-brown tint that the eastern locality seems to be unable to produce, together with the enlargement of the spots, and commencing coalescence, to form the band of *butleri*. Another transition can be seen between *confusa* and *fulvescens* : the fore-wings have the ground-colour of a deep brown, sometimes with light brown patches outside the spots, which are white. The central area of the hind-wing is light brown, and the broad border of a darker brown, or it may be nearly of the same colour as the fore-wings. These transitions are nicely shown in some specimens from Dabida Mountain captured by the Rev. K. St. A. Rogers in 1926–27.

Form **valdemaculosa,** f.n. (Pl. XIV, fig. 9).

A form of *confusa* has been developed in the eastern, and especially in the southern, areas which so greatly preponderates in Nyasaland that it seems worthy of a name, and I therefore now describe it as new. It is characterised by the large size and pure shining whiteness of the pale areas in both sexes, although more strikingly developed in the female. The figure sufficiently shows the appearance of the female.

Eltringham (19, Pl. I, fig. 13) figures a specimen of approximately this form from Usambara, but the highest development is in Nyasaland, on Mt. Mlanje.

Type ♀ in the British Museum. NYASALAND: Mt. Mlanje, 16.iv.1913 (*S. A. Neave*).

Form *flavescens*, Oberth. (Pl. XIII, fig. 8).

This is of the general appearance of *confusa* but has the spots on the fore-wing pale yellow. Yellowness of these spots appears to be entirely a male character. Not only is every one of the 302 specimens reviewed in this paper of the male sex, but in the form *semialbescens* among the Didinga specimens (30) those with the fore-wing spots yellow are of the male sex.

Form *semialbescens*, Oberth. (Pl. XIII, fig. 7).

This has blackish fore-wings, with rather large white or yellowish-white spots in the *confusa* pattern, and the pale area of the hind-wings a rich tawny, or light chestnut, brown. Like all forms it is variable and often shows tawny radiate markings running out towards the margin in the anal half of the hind-wing, and there may be streaks of the same colour along the chief veins of the fore-wing.

Other specimens show a suffusion, around the spots of the fore-wing, with the same tawny or chestnut colouring, and form a connecting link with the form *octobalia*. The table shows that *semialbescens* is one of the least common forms, and it is a little difficult to place it in series among the others. The very strongly brown hind-wing has a broad black border so that it does not lead easily to form *fulvescens*. Possibly it is developed from *confusa* by intensification of the often yellowish hind-wing central area to a deeper hue of brownish, or tawny, colour. An extremely interesting specimen captured by Lamborn in Nyasaland shows the transition well: the fore-wings are of a very deep brownish-black with lighter brown between the spots; the hind-wing patch is of the typical *semialbescens* tawny colour but the indentation into the black margin is almost white.

Form *fulvescens*, Oberth. (Pl. XIII, fig. 3).

This is slightly more plentiful than *johnstoni* itself and seems to be mimetic of *Danais chrysippus*. Very variable in appearance, it has both wings light brown with the spots on the fore-wing of varying degrees of conspicuousness, sometimes being almost indistinguishable and in other specimens (see next form) becoming pure white. The amount of black border and of general black suffusion is extremely variable. The black border of the hind-wing is almost painted out by the general brown ground-colour, but can usually be traced. The shade of light brown ground-colour varies greatly from a rich orange, or even dark, brown, to a light sandy colour; and the hind-wings may be yellowish-white.

Form **pretiosa,** f.n. (Pl. XIII, figs. 4 & 5).

This form is distinguished from *fulvescens* by the large size of the pure shining white fore-wing spots, just as the other form from the same locality, described previously as *valdemaculosa* is distinguished from *confusa.*

The striking appearance of this form is well shown by the figures. The name *pretiosa* is chosen to record the silver spots on the golden yellow-brown ground-colour. The latter, however, may be somewhat suffused with black, and in some cases there is obvious transition to the form *valdemaculosa*, the brown ground-colour being very dark, though not completely blackish-brown. The darker border of the hind-wing is usually marked off from the rest of the wing quite clearly, though, as in *fulvescens*, the whole hind-wing may be of the same hue. The veins of the wings are generally rather more distinctly marked with black than in *fulvescens.*

This form is characteristic of Nyasaland, though it also occurs in the eastern parts of Kenya on Dabida Hills, area 4. The table shows that 44 specimens are recorded from Nyasaland and only 1 *fulvescens*, so that it almost completely replaces *fulvescens* there.

NYASALAND : Mt. Mlanje, 13.v.1913 (*S. A. Neave*), ♂; PORT. E. AFRICA : Mt. Chiperone, 1700 ft., 3.xi.1913 (*S. A. Neave*), ♀. Type in British Museum.

Form *octobalia*, Karsch.

This is a scarce form, having the spots of the fore-wing and basal patch of the hind-wing tawny yellow. Being a transitional form, it is not very stable. It seems to occur throughout East Africa, but not in the Sudan or Rhodesia.

Form *praelongata*, Joicey & Talbot (Pl. XIII, fig. 9).

This exceptionally interesting form shows how *butleri* could have arisen from *confusa.* The specimen illustrated comes close to the description given by Joicey & Talbot (29). The anterior spots are enlarged to form a band, and the two posterior spots touch each other. The pale area of the hind-wing is yellowish-white, and on the underside of the hind-wing is a basal triangle of reddish-brown, suggestive of the characteristic basal aposeme of *Planema*, which is highly significant. The basal black spots, which in most forms of *johnstoni* are irregularly disposed over a patch of ground-colour of more reddish tinge than the rest of the wing, are in this specimen confined to the outer edge of the patch, which is larger and redder than usual. A most significant feature is the peculiar tint of the ground-colour of the fore-wing, which has a decided reddish tinge on the inner side of the posterior spots so that the wing has a slight degree of the purplish hue so typical of *butleri.* The type specimen, a female in the Joicey collection in the British Museum, came from L. Mweru district, S.E. Congo, and two male specimens, approaching the type are in the Tring Museum : one came from Kwidgwi isle in L. Kivu, the other, which is figured, from the volcanoes at the north end of L. Kivu. It is most interesting that, just where the distribution of *confusa* comes nearest to that of *butleri*, the intermediate form should appear; and this furnishes a strong argument that *butleri* has arisen in this way, and not from such a variety of *confusa* as has previously been mentioned as occurring in East Africa.

Form *butleri*, Auriv. (Pl. XIII, figs. 10–12, and Pl. XIV, fig. 3).

This, with the exception of the transitional form *praelongata*, is the only one occurring in the western area, No. 10.

It is a beautiful mimic of *Planema quadricolor latifasciata*, E. Sh., having the basal half of the fore-wing of the same curious purplish-brown hue and divided from the black apex by an orange band. The pale area of the hind-wing is yellow or yellowish-white. An important part of the mimetic appearance is the undersurface of the base of the hind-wing, where the typical red basal triangular aposeme of the *Planema* is well reproduced with the spots along its outer edge. In no other form of *johnstoni* is the basal red of this appearance, except in *praelongata*, nor are the spots concentrated along the outer edge. The male *butleri* is not so good a mimic as the female, for the orange band, even in its most developed state in this sex, is rarely so complete. The weak point is in area 3 of the fore-wing, where the orange may be only represented by a minute patch, so that there is a distinct break between the two groups of spots, as is well shown in Grose-Smith's coloured figures (14), and in Pl. XIII, fig. 11.

Attention has been previously drawn to a variety of *confusa* in E. Africa with a large white patch in area 3 of the fore-wing, and the importance of this patch in the development of the full mimetic likeness to the *Planema* is obvious.

Neave, on the extreme eastern border of the range of *butleri*, namely western Ankole, captured four males of a very elementary form of *butleri* of which one is shown in Pl. XIII, fig. 10. It differs very little from the specimen of *praelongata* shown above it, but there is a more decided purple tint of the base of the fore-wing, though the full development of the purple has not been reached. The spots are in pattern the same as in the *praelongata* but more decidedly yellow, though not orange. The locality from which these specimens came, together with three normal *butleri*, is (probably) beyond the range of the western *Planema*, so that the mimetic appearance is not kept up to standard.

Aurivillius refuses to admit *butleri* as a form of *johnstoni* as " it differs from *johnstoni* in the black palpus and in having the spots of the fore-wing quite differently developed " (25). But the specimens illustrated show how the spots of *confusa* grade into those of *butleri*, and, as regards the palpi, the specimen of *praelongata* is as intermediate in this as in other points, the lower surface having a few pale scales among the black hairs. The most important feature of *butleri* is the modification of the ground-colour to a purplish tint combined with enlargement of spots. This appearance, in its two separate components, is occasionally reproduced in the eastern area of the distribution of the species (see above, under *confusa*), but the components have not there been intensified and combined into the mimetic likeness to the *Planema*. This will be discussed later.

Form *silvicola*, Richelmann.

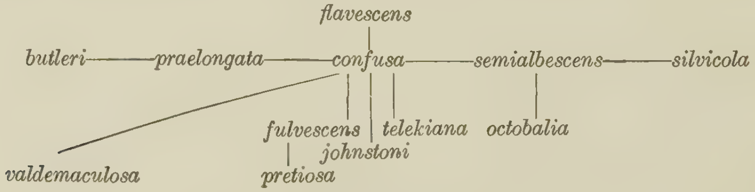
This most interesting form is at present represented by a unique specimen from Usambara (area 4), and I have seen nothing approaching it. It is modified to resemble *Danais chrysippus chrysippus*, L., having the fore- and hind-wings reddish-brown, with the apex of the fore-wing black in which the two anterior spots of *johnstoni* show up pure white. The posterior pair of spots are not visible. The hind-wing has a narrower black border than is usual in *johnstoni*, and there is no angulation of the central patch. I suggest that this wonderful form may have arisen by a mutation from *semialbescens* ; the coloration seems similar to that of the hind-wing of that form. Further knowledge of it is much to be desired.

THE PROPORTIONS OF THE SEXES.

The 1668 specimens the sex of which was noted give a female percentage of 34·3: an illustration of the well-known fact that females are less commonly captured. It is of interest to determine whether any variety is commoner in the female sex than the average, and in the following table the percentage of females is stated for each form. The form *confusa*, alone, shows 51% females, but the excess over the average is accounted for by *flavescens* being only male. If the two forms are taken together, it is seen that the female percentage is 25·5. If all the *Amauris*-like forms are taken together, adding *valdemaculosa* to the other two, the female percentage, 32·2, shows that there is no departure from the average in females with an Amauroid-appearance.

Females of the form *fulvescens* are slightly less common than the average, by 12·3%, whereas in *johnstoni* there is no difference. The form *butleri* would seem to be abnormally difficult to collect in the female sex, which is less than the average by 16·4%. This cannot be due to the female appearing in other guises, for in the locality where *butleri* occurs there is no other form to be considered in this way. We must therefore conclude that the female *butleri* is more than usually different from the male in its habits, for one cannot suppose that in area 10 the species is represented by much fewer females than in other areas. Finally, the form *semialbescens* would seem to be more especially a female form, as its percentage is greater than the average by 13·3.

The following schematic table of the forms is an attempt to represent them in their relationship to each other.



DISTRIBUTION.

The characteristics of each form having been discussed, we will consider the area inhabited by the species and the varying proportions of the different forms in the sub-areas into which the general habitat can be divided, and these will now be dealt with in turn.

Area 1. The figures for the South-Eastern corner of the Sudan are almost entirely made up by a collection from the Didinga Mountains (30); three specimens only have been recorded from the Imatong Mountains,* a range to the west separated by some 50 miles of dry plain. One specimen was taken by Major F. Moysey. The second is in the collection made by Capt. A. L. Kent-Lemon, and the third is in the Joicey collection in the British Museum. *A. johnstoni*, while abundant locally in Didinga, is thus a rarity elsewhere. The very fine collection made by Mr. Arnold W. Hodson, and presented to the Hope Department, from S.W. Abyssinia, contains only a single specimen, so that the species seems to have an equally precarious footing in Abyssinia. The table shows that *confusa* and its close ally *flavescens* make up 83% of the total, the remainder being *semi-*

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* Since this paper was written, I have seen another specimen of *flavescens* from the Imatong Mts. through the kindness of Captain and Miss Owen.

Form.	Percentage of total.	Area 1.		Area 2.		Area 3.		Area 4.		Area 5.		Area 6.		Area 7.		Area 8.		Area 9.		Area 10.		Totals.		
		♂.	♀.	♂.	♀.	♂.	♀.	♂.	♀.	♂.	♀.	♂.	♀.	♂.	♀.	♂.	♀.	♂.	♀.	♂.	♀.	♂.	♀ Percentage and number. ♀.	T.
confusa	38·3		74	48	30	39	32	75	54	6	10	6	1	11	3	113	117	12	8			310	51% 329	639
flavescens	18·1	51		14		18		32				3				175		9				302	0%	302
fulvescens	10·1			25	7	7	3	81	22	9	6	7				1						130	22% 38	168
valdemaculosa	8·5				1			11	20							66	44					77	45·8% 65	142
johnstoni	8·0			25	9	11		42	34	5	4	3	1									86	35·8% 48	134
butleri	5·1																			64	14 + 8 not sexed	64	17·9% 14 + 8 not sexed	86
semialbescens	5·0	6	19	7		6	5	10	7	2		1				12	9					44	47·6% 40	84
pretiosa	2·7							2								34	10					36	21·5% 10	46
octobalia	0·8			2		1		3	2				1			4						10	3	13
praelongata	—																			2	1	2	1	3
silvicola	—								1														1	1
intermediate specimens unclassible	3·0																					29	21	50
Totals		57	93	121	47	82	40	256	140	22	20	20	3	11	3	405	180	21	8	66	15 + 8 not sexed	1090	34·3% 570 + 8 not sexed	1668

albescens. The chief interest of this locality is that here the species has become sexually dimorphic. All the specimens with the spots on the fore-wings yellow are males, and there are no males of the form *confusa.* This distinction even holds with the *semialbescens,* of which all the male specimens have the spots yellow, the females, white. By contrast, the closely allied species *lycoa* occurs in Abyssinia in only one form, *aequalis,* R. & J., with sexes alike, while elsewhere it is always dimorphic. This is an example of the difficulty of ascribing the appearance of a species merely to its climatic or geographical environment. As these two close allies are followed to the furthest N.E. corner of their distribution one becomes sexually dimorphic, the other, monomorphic !

Area 2 occupies the neighbourhood of Mt. Elgon, and the Kavirondo country and Tiriki Hills near the N.E. portion of L. Victoria. All the main forms (save *butleri*) are represented here in the following percentage proportions : *confusa* with *flavescens* 54·8, *johnstoni* 20·2, *fulvescens* 19·0, and the remainder made up by *semialbescens* 4·2, *octobalia* 1·2 and *valdemaculosa* 0·6. This area does not extend westwards much beyond the base of Elgon. There is complete discontinuity in the distribution of *johnstoni* westwards ; it does not occur between the Elgon neighbourhood and Ankole in the western province of Uganda. Very large collections made by Dr. C. A. Wiggins, C.M.G. (Neave 32) in the neighbourhood of Entebbe on the north coast of L. Victoria, by myself on the Sese Islands and the coast of the Lake, and in the Tero forest close to the west shore of the lake on the southern border of Uganda, and by other observers whose collections have been examined in the Hope Department, show that *johnstoni* is not to be found along the north and west coast of the lake nor on the islands : its place is entirely taken by *lycoa*. A possible explanation is that, while *lycoa* occurs in really thick forest, *johnstoni* frequents bush rather than forest, and even on mountains its habitat is more in clearings than in primitive forest. *A. lycoa* on the other hand is found in the type of environment chosen by the genus *Euphaedra* and its allies, which is the prevailing type of country, apart from grassland, along the north and west shores of the lake.

But, out of the 1668 specimens examined, an exception must be made to the above statement. The Tring Museum possesses a single male *confusa* taken at "Kisilea, W. coast of L. Victoria." While it is of course possible that there has been a mistake in the data, it is better to suppose that this individual was a wandering specimen, not representing a real habitat; it may have been blown across the lake. If the species really lived in that area, it must have been collected in greater numbers, and this record is not placed on the map, to avoid giving a false impression.

Area 3 centres round Nairobi and embraces Mt. Kenya. All the described forms are found there, except *butleri* and the two new forms described previously, in the following proportions: *confusa* with *flavescens* 73%, *johnstoni* 9%, *semialbescens* 9%, *fulvescens* 8%, and *octobalia* 1%.

Area 4 comprises Kilimanjaro and the rest of the higher part of Usambara, and extends northwards to Taveta and the Dabida Hills. This area comes second in order of number of specimens, supplying 396; the proportions of the forms are as follows, all the named forms except those of the western area being represented. *Confusa* with *flavescens* 41%, *fulvescens* 26%, *johnstoni* 19%, *valdemaculosa* 8%, *semialbescens* 4%, *octobalia* 1·5%, *pretiosa* 0·5%, and the form *silvicola* is represented by the only known specimen.

Area 5 comprises the coastal strip from Mombasa and the Rabai hills through Dar-es-Salaam to Lindi. No specimens from Zanzibar island have come to my notice. The proportions are as follows : *confusa* 38%, *fulvescens* 35%, *johnstoni* 22%, *semialbescens* 5%. The 42 specimens supply no example of *flavescens* and it is evident that the species is not abundant along the coast.

Area 6 embraces part of the interior of Tanganyika Territory in the Itumba neighbourhood, Iringa, Mpapwa, and Morogoro being included. The 23 specimens show that the prevailing forms are, *confusa* with *flavescens* 43·5%, and *fulvescens* 30%, with 17% *johnstoni*, but the total number of specimens is too small for these proportions to be of any value. *Octobalia* is represented by a single specimen.

Area 7 lies at the south end of L. Tanganyika and N. end of L. Nyasa, embracing portions of the Congo, Tanganyika Territory and N.E. Rhodesia, and sends up an arm to M'pala, S. of Albertville, on the west side of L. Tanganyika. The 14 specimens recorded from this area are all of the form *confusa.* The area is of importance, because through it, rather than through the country west of area 2, probably lies the connection with area 10, and other specimens will probably turn up from the west side of L. Tanganyika : at present there is only one, from M'pala. The significance of this will be discussed under area 10.

Area 8 comprises the southern part of Nyasaland and a small part of Portuguese East Africa to the immediate south of it. Its *johnstoni* fauna shows the following remarkable features : *confusa* with *flavescens* 69%, *valdemaculosa* 19%, *pretiosa* 7·5%, *semialbescens* 3·5%, *octobalia* 0·7%, *fulvescens* 0·3%. Adding *valdemaculosa,* which is only *confusa* with large white areas, to *confusa* with *flavescens* we see that 88% are of the *confusa* form in general. The great majority of the 585 specimens in this area are from Mt. Mlanje. The chief characteristic of this area is the development of the spots to a much greater degree of conspicuousness. Grouping together the two newly described forms *valdemaculosa* and *pretiosa* we see that 26·5% of the total *johnstoni* show this peculiarity, which is only exemplified in area 2 by 0·8% and in area 4 by 8·5%. To such an extent has it been developed that all of the form *fulvescens* save *one specimen* are of this, now separated, form, with the large brilliantly white spots. It is clear that Nyasaland is the headquarters of the large-spotted forms, which occur to a smaller extent in areas 4 and 5. In area 4, 8% of the total are of the modified *confusa,* now described as *valdemaculosa.*

Area 9 is the southern outpost of the species. It embraces a small part of S. Rhodesia, the Chirinda forest and Umtali. The few specimens from here are 20 *confusa* and 9 *flavescens,* and it is interesting that typical *valdemaculosa* is not recorded.

Area 10 is of great interest and the most important from the point of view of this paper. It is isolated : it is the westernmost area of *johnstoni* and occupies a part of Africa which provides many features of interest. The area lies along the great rift forming the Uganda-Congo border from a point on the western shore at about the middle of L. Albert to the region around the N. end of Tanganyika : it extends eastwards as far as Western Ankole in the western province of Uganda, and westwards to the upper Lowa valley of the Congo. This is the home of *butleri* which was first taken on Ruwenzori, and afterwards named *toruna* from being taken in Toro, W. Uganda.

The point that is now made is that, with the proviso following, in area 10 *butleri* is the only form and that it occurs nowhere else. The exception to this statement is provided by the three specimens of the recently described form *praelongata,* and the fact that the only specimens recorded come from L. Kivu and the S.E. Congo suggests a geographical link, just as the form itself is a morphological link, with *confusa.* For *confusa* (see area 7) may well be in contact with the south end of area 10, and it is here that the intermediate forms occur. It is also of interest that the least typical of the 85 specimens of *butleri* recorded come from the easternmost part of area 10, viz. W. Ankole where Neave took specimens which are obviously an elementary stage.

Thus we have a true geographical race in *butleri* which, in the directions of the nearest habitats of *confusa,* shows intermediate forms. Indeed, it is so isolated that it has almost become a separate species : Eltringham (19) has recorded that the genitalia do show a very slight difference from those of the other forms, and the characteristic appearance of the palpi has been already noted.

DISCUSSION.

The different forms, and their varying prevalence in different areas, having now been described, it remains to be seen whether any explanation is available.

The chief points of interest are the exclusive occurrence in the west of a form found nowhere else, and the development in the south of forms in which the white markings are more pronounced. Other points are, the limitation of the form *johnstoni* to the central area of the habitat of the species, and the absence of form *fulvescens* from the northern and southern extremes.

The Incidence of butleri *in Area* 10.

One point that emerges quite clearly from the distribution of *butleri* is that mere environment cannot be called in to explain likeness between two different species in the same area. For although *Planema quadricolor latifasciata*, E. Sharpe, and *Acraea johnstoni butleri*, Auriv., occur together on Mt. Ruwenzori in W. Uganda (Pl. XIII, figs. 2 & 3) there are no *butleri* on Elgon in E. Uganda where the *Planema* occurs in precisely the same form as on Ruwenzori (fig. 1).

The locality Itumba in area 6 appears to be the most southerly in E. Africa inhabited by *P. quadricolor*. On the west it extends from Ruwenzori southwards along the Rift Valley to Urundi at the north end of L. Tanganyika as far as the Kabira forest, 25 miles south of Usumbara. I am greatly indebted to Mr. Talbot for this information regarding the western area.

It is only the form *latifasciata* with which *Acraea johnstoni* enters into synaposematic relationship to a noteworthy degree. The resemblance of *johnstoni* to *quadricolor quadricolor* mentioned by Poulton (15) is very elementary.

The following record of collections made by myself on Ruwenzori and Elgon exemplify well the presence of the *Planema* in both areas, and the absence of *butleri* from the latter, while it is the only form of *johnstoni* in the former.

Ruwenzori (Jan. 1928).			Elgon (Dec. 1928–Jan. 1929).		
	♂.	♀.		♂.	♀.
P. quadricolor latifasciata	15	14		27	21
A. johnstoni butleri	10	4		0	0
,, other forms	0	0	*johnstoni*	7	1
			confusa	9	3
			fulvescens	4	1
			transitional	3	2

If the occurrence of *butleri*, exclusively, with the *Planema* on Ruwenzori is due to environmental conditions acting similarly on two species to produce a common coloration, how is it that when the same species of *Acraea* occurs abundantly with the same *Planema* on Elgon, the former is no longer influenced by the conditions that have maintained the *Planema* in the same form as on Ruwenzori? Some other explanation must be sought. It is legitimate to suppose that the isolated western *johnstoni* may have thrown off a variation which has not been produced in the eastern area. The characteristics of *butleri* are enlargement of spots and development of extra spots, to form a band; and secondly, the peculiar purplish tint of the brown at the base of the forewing. If these characteristics cannot be found in the east, the above supposition would be strengthened. The specimen shown in Pl. XIV, fig. 10, shows that the necessary alteration of spotting has been produced; a comparatively slight change from white to yellow would produce a likeness to an elementary *butleri* such as is shown in Pl. XIII, fig. 10. The purplish-brown tint also is closely approximated in the east by occasional specimens of a transition between *confusa* and *johnstoni* in which the black and tawny scales are so intermixed over a great part of the wing that a distinctly purple hue is given (*vide supra*, p. 254 under *confusa*). But comparison under the lens shows that this similarity is not a real one. In true *butleri* the purplish colour is in the scales themselves, and is not due, as in the transitional specimen, to intermixture of black and brown scales. So far as the characteristic tint of *butleri* is concerned, therefore, it seems only to have been produced in the west, which provides some explanation of the localisation of *butleri*. But a further explanation may be sought in the possible influence of other Lepidoptera in the localities frequented by *johnstoni*.

The table shows that the greater number of the specimens are of the forms resembling *Amauris*, viz. *confusa*, *flavescens*, and *valdemaculosa*: for in all areas except 10 no less than 60% of the total number of specimens recorded have this appearance. On Ruwenzori *Amauris* species of the types serving as models are not very noticeable, whereas further east they abound. Moreover, in an interesting paper, Neave showed (32a) that west of L. Victoria the white hind-wing markings, and to a less degree, the fore-wing spots, become less and less conspicuous as the species are traced into the Congo, apparently under the influence of the dark western species *hecate*, Btlr., etc. It may therefore be at least presumed that in the west *Planema quadricolor* is the chief model, and exercises a greater " attractive " power than the less conspicuous *Amauris*. In the east it only occurs on the mountains or at any rate high elevations, where it has to compete, as a model for *johnstoni*, with numerous strongly marked *Amauris*; and in many places, *e.g.* the lower ground around the east of L. Victoria, or around Nairobi, it is out of the reckoning altogether. Over the greater part of its eastern range *johnstoni* is more under the influence of *Amauris* than of *Planema*, and we find that the Amauroid form is the more abundant.

The Preponderance of valdemaculosa *in Area* 8.

Reference to the table shows that a few of this form are found in area 4 in the Kilimanjaro neighbourhood, but that its maximum abundance is in area 8, Nyasaland, where it is in a proportion of 21% of the Amauroid forms. In this locality there is a large *Amauris* population with strong white markings of the type shown in Pl. XIV, fig. 8, which exemplifies *A. dannfelti*, Auriv. Besides this there is the form *crawshayi*, Btlr., of *A. lobengula*, and *A. psyttalea*, Plötz, with *albimaculata* combining to produce a striking feature of the fauna. The larger spots of *A. ochlea*, Bsd., must also contribute to the black and white effect, although the pattern is somewhat different on the fore-wing. It appears that in Nyasaland there is a sufficiently large population of strongly-marked *Amauris* to draw after it a certain number of the *johnstoni*, the form *confusa* being modified accordingly.

In Rhodesia (area 9), *johnstoni* is not so plentiful, and only 29 specimens were available for record. While none of them is the fully developed form *valdemaculosa*, a number of specimens of *confusa* do show an enlargement of spots, as mentioned by Poulton (15, p. 300).

The presence of a few *valdemaculosa* in the Kilimanjaro neighbourhood (area 4) is quite possibly to be explained by the presence of *Amauris albimaculata hanningtoni*, Btlr., with large white markings. Rogers says (33) " In Taita *A. albimaculata* always has the large patch in the centre of the hind-wing very pale ochreous, but this is not the case with those I have seen from Nairobi and the

Kenya district. I have examined scores of *A. albimaculata* in Taita and they are singularly uniform." Van Someren and Rogers, also, say (34) of *hanningtoni*, "this insect has been described as a race of *albimaculata*, the main features being the very pale creamy hind-wing patch and the often numerous spots in the hind-wing. This is the predominant form in the Kilimanjaro Taita area, extending north to L. Victoria. The majority of the Nairobi specimens, however, are considerably darker. . . ."

Thus it appears that in area 4 the presence of a few *valdemaculosa* coincides with a local form of *Amauris* which it resembles.

The small-spotted, dark form of *confusa* shown in Pl. XIV, fig. 7, with its model above it, is the characteristic form in area 2 on Mt. Elgon where the strongly white-marked *Amauris* are not noticeable.

A curious point is the presence in area 8 (Nyasaland) not only of a form of *johnstoni* derived from *confusa* by enlargement of the spots of the fore-wing (*valdemaculosa*), but a similar form derived in the same way from the form *fulvescens*, and now described as *pretiosa*. This striking form cannot be said to be mimetic of anything, but it would appear to owe its large white spots to the locality in which it occurs so abundantly. It is possible that, as *confusa* is by far the commonest form of *johnstoni*, the character of large-spottedness first arose in it, and has been transferred to *fulvescens*, thus causing the new form.

The Absence of fulvescens *from Areas* 1, 7 *and* 9.

The absence from the S.E. Sudan of the form of *johnstoni* which mimics the form *dorippus* of *Danais chrysippus* is indeed surprising, seeing that it is in this area that *dorippus* would be expected to be more plentiful than in other areas inhabited by *fulvescens*, for *dorippus* is more especially a desert form. The total number of specimens collected is large enough to have yielded *fulvescens*, if it were present in the same proportions as elsewhere (about 16%). In localities 7 and 9, however, it may be that the number of specimens is too small to reveal the presence of *fulvescens*.

If the diagram on p. 258 showing the origin of the different forms from *confusa* represents the real state of affairs, it becomes possible to suppose that the species only having recently spread outwards from its centre, probably area 4, *fulvescens* has not yet arisen. The only variation that seems to have occurred in area 1 is the darkening of the hind-wing to form *semialbescens*.

The Absence of form johnstoni *from Areas* 1, 7, 8, 9.

The normal form of *johnstoni* cannot, I think, be ascribed with any confidence to the influence of other species; it is not a mimic. But it is extremely variable, and one of its forms (Pl. XIV, fig. 5; the specimen figured by Eltringham (18)) can be claimed as a mimic of *Planema poggei*. But the distribution of this much-mimicked species does not agree with that of *johnstoni*. From facts that Mr. Riley and Dr. Jordan have kindly supplied, it appears that the areas inhabited by *johnstoni* are just those in which, broadly speaking, *poggei* does not occur. The latter ranges, in the south, from Katanga, N.E. Rhodesia (L. Kalungwisi) and the interior of Angola, northwards through the Congo (just extending into the western border of Tanganyika Territory at Kigoma on the east coast of the lake) and eastwards into Uganda, the S.E. corner of the Sudan, and Abyssinia. In Kenya Colony it does not occur further east than the Nandi–

Elgon area (35). Harrison recorded a specimen from " Nairobi " (Poulton, 15, p. 303), but this is very probably an error in data.

Poulton's (15, p. 303, and Pls. XX and XXII) suggestion that this specimen of *johnstoni* mimics *Papilio dardanus planemoides*, Trim., rather than the *Planema* itself, is therefore probably the explanation, as *planemoides* extends further east than *poggei*. Notwithstanding this specimen, the form *johnstoni*, as said previously, is not a mimic; being very conspicuous on the wing, and a distasteful species, it can probably hold its own among other forms. Indeed, as Poulton has pointed out, polymorphism is an advantage in that it distributes any loss to the *species* that may occur by experimental tasting over a variety of *forms*, so that the species may still survive, carried on through the medium of one form even if another is destroyed (36).

It will have been obvious that this paper has been written by a believer in the interpretation of the phenomena of mimicry by the Darwinian principle of Natural Selection. There is no other that explains so many facts; the study of the geographical variations of *Acraea johnstoni* shows that predominance of a form in a certain locality can be explained by the presence of other species in the same area; the inorganic environment cannot be called upon to explain certain facts cited in this paper.

Finally, an appeal is made to those in East Africa who are in a position to carry out breeding experiments, to remember this common species. The occurrence of a form in one sex only (*flavescens*) and the isolated race *butleri*, would make the breeding of a series of generations of interest. It should be easy in these days of rapid transport to obtain, and transport to Kenya Colony, eggs or larvae of the form *butleri* and to determine whether the imago is fertile with other forms.

The food-plant is stated by Van Someren and Rogers (28) to be *Ponzolzia parasitica*, Urticaceae (native name " Schewanfo "); a plant that grows on the borders of open areas of forest where there is sufficient moisture and shade.

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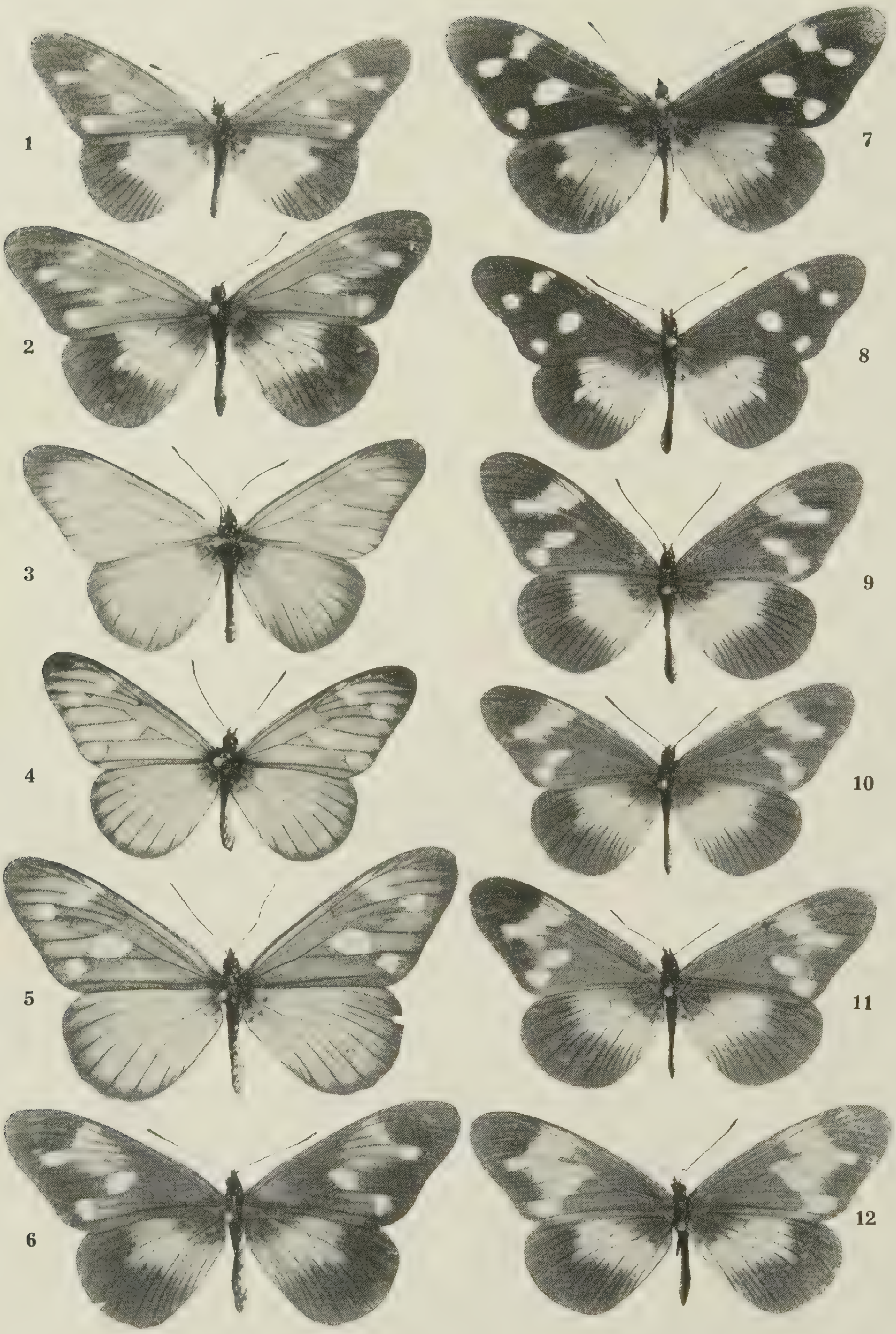
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A. Robinson, Photo. *Natural Size.*

Forms of *Acraea johnstoni*, **Godman.**

EXPLANATION OF PLATE XIII.

Forms of *Acraea johnstoni*, Godman.

All specimens in the Hope Department, Oxford University Museum, unless otherwise specified.

FIG. 1. Form *johnstoni*, Godm. ♂. Tanganyika Territory, Usambara, Mabirioni, Tanga-Moshi R'y. July 14, 1916. *W. A. Lamborn.* Very little black suffusion of fore-wing, spots cream-coloured on tawny ground: central area of hind-wing white.

2. Form *johnstoni*, Godm. ♀. Uganda, E. Province, Mbale station, near Mt. Elgon. Aug. 10, 1911. *S. A. Neave.* No black suffusion of fore-wing: spots very little lighter than tawny ground-colour: central area of hind-wing white.

3. Form *fulvescens*, Oberth. ♂. Kenya Colony, Dabida Mt., Taita, 100 m. N.W. Mombasa. May 30, 1904. *K. St. A. Rogers.* Very uniformly coloured light brown: the spots only slightly paler and the broad border of the hind-wing scarcely differentiated: a narrow black margin only.

4. New form *pretiosa*, mihi. ♂. Nyasaland, Mt. Mlanje. May 13, 1913. *S. A. Neave.* British Museum. Differs from 3 in large size and shining whiteness of spots.

5. New form *pretiosa*, mihi. ♀. Port. E. Africa, Mt. Chiperone, 1700 ft. Nov. 3, 1913. *S. A. Neave.* British Museum. Differs from 4 in being slightly suffused with black.

6. Transitional form. ♀. Uganda, Mt. Elgon, Bulago camp, 7000 ft. Dec. 23, 1928. *G. D. Hale Carpenter.* Fore-wings like *johnstoni* with much black suffusion at base: spots very little different from surrounding tawny ground-colour. Hind-wing with strongly marked black patch at base, the paler area tawny. Might be classified as a form of *octobalia*, Karsch.

7. Form *semialbescens*, Oberth. ♀. S.E. Sudan, Didinga Mt., Nagichot, 6700 ft. Jan. 4, 1926. *G. D. Hale Carpenter.* Spots of fore-wing pure white; central area of hind-wing tawny.

8. Form *flavescens*, Oberth. ♂. S.E. Sudan, Didinga Mt., Nagichot, 6700 ft. Jan. 1, 1926. *G. D. Hale Carpenter.* Spots of fore-wing, and central area of hind-wing lemon yellow.

9. Form near *praelongata* ♂, Joicey & Talbot. ♂. North end L. Kivu. Mt. Ninagongwe, 1900–3000 metres. End of September 1907. *R. Grauer.* Tring Museum. Spots of fore-wing white, central area of hind-wing yellowish-white. Ground-colour of fore-wing very slightly suffused with reddish scales. Cf. Pl. XIV, fig. 10.

10. Elementary form of *butleri*, Auriv. ♂. Uganda, Western Province, west of Ankole, forest, 4500–5000 ft. Oct. 14, 1911. *S. A. Neave.* British Museum. Spots of fore-wing and central area of hind-wing dull yellow: base of fore-wing slightly purplish-brown.

11. Form *butleri*, Auriv. ♂. Same data as 10. Spots of fore-wing orange, central area of hind-wing tawny, with darker streaks. Base of fore-wing purplish-brown.

12. Form *butleri*, Auriv. ♀. Uganda, W. Province, Toro, Mpanga forest, 4800 ft. Nov. 13, 1911. *S. A. Neave.* British Museum. Fore-wing bar orange: base of fore-wing purplish-brown. Central area of hind-wing tawny, paler along inner margin, streaked with darker tint.

EXPLANATION OF PLATE XIV.

Forms of *Acraea johnstoni*, Godman, with species to which they have synaposematic resemblance.

All specimens in the Hope Department, Oxford University Museum.

FIG. 1. *Planema quadricolor latifasciata*, E. Sharpe. ♀. Uganda, E. Province, Mt. Elgon, Bugananya, 7000 ft. Nov. 29–30, 1924. *G. D. Hale Carpenter.* Bands on fore- and hind-wing orange, base of fore-wing purplish-brown.

2. *Planema quadricolor latifasciata.* ♂. Uganda, W. Province, Toro, 7000–9000 ft. Nov.–Dec. 1900. Native collector of *C. A. Wiggins.* Description as 1. Model for 3.

3. *A. johnstoni butleri*, Auriv. ♂. Data as 2. The band on the fore-wing is unusually complete for a male. Cf. with figs. 10 and 11 on Pl. XIII. Mimics 2.

4. *Planema poggei*, Dew. ♂. Uganda, E. Province, Busitema, between Mt. Elgon and L. Victoria, 4000 ft. Jan. 1923. *G. D. Hale Carpenter.* Band on fore-wing orange, on hind-wing white. Model for 5.

5. *A. johnstoni johnstoni*, Godm. ♀. Kenya Colony, Taveta, 2500 ft. May 15, 1905. *K. St. A. Rogers.* Fore-wing black at base: spots dull yellow, area between spots orange. Hind-wing white central area. Mimics 4. An unusually large specimen.

6. *Amauris albimaculata*, Btlr. ♂. Uganda, E. Province, Mt. Elgon, Bulago, 7000 ft. Dec. 25, 1928. *G. D. Hale Carpenter.* Spots of fore-wing white, central area of hind-wing yellow. A small specimen of the type serving as model for 7.

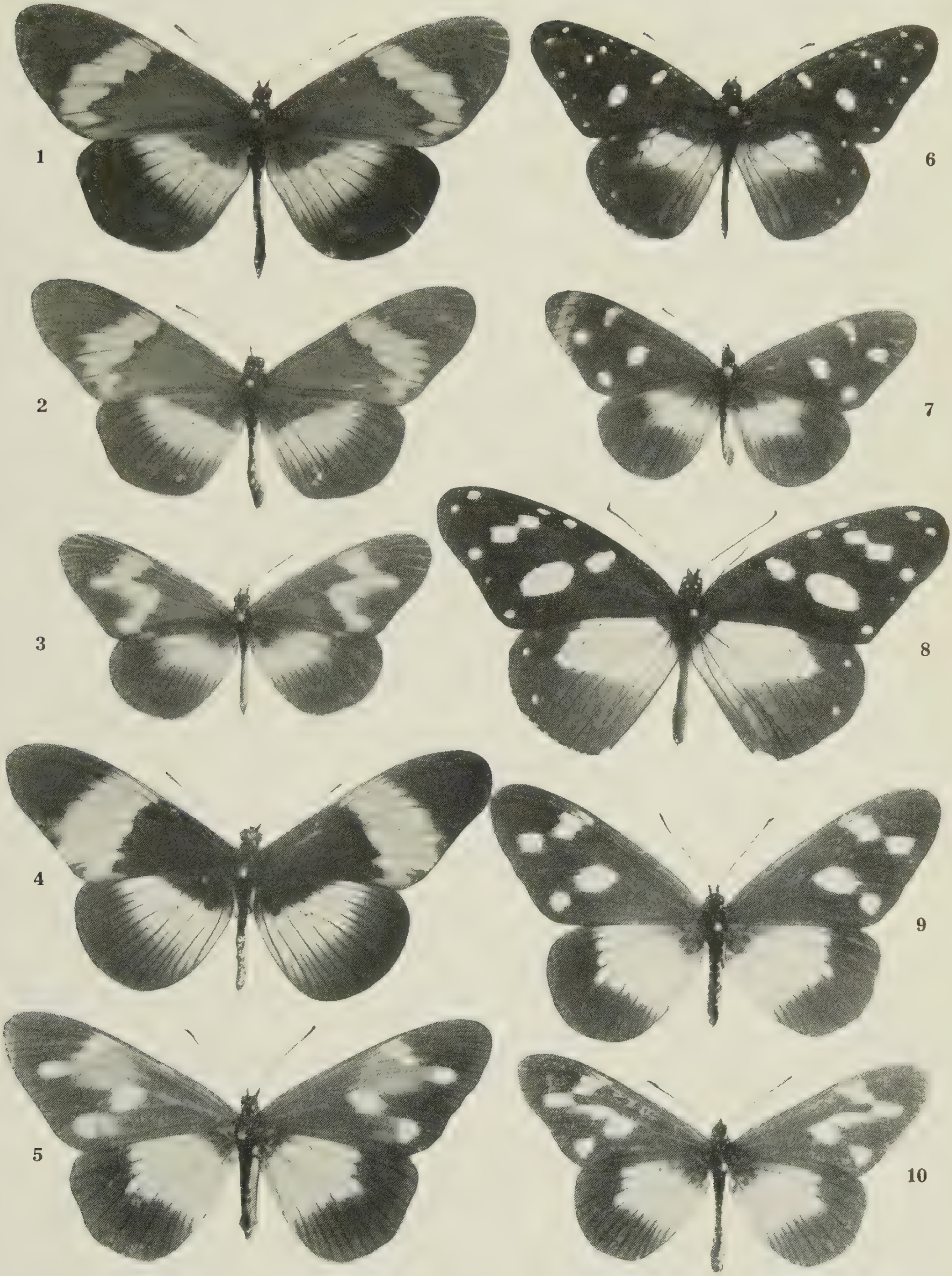
7. *A. johnstoni confusa*, Rog. ♂. Same locality as 6. Dec. 24, 1928. *G. D. Hale Carpenter.* Spots on fore-wing white, central area of hind-wing yellow. Mimics 6.

8. *Amauris dannfelti*, Auriv. ♂. N.E. Rhodesia, N. Lake Bangweolo, Luwingu, 4200 ft. July 18, 1908. *S. A. Neave.* Black and white. Model for 9.

9. *A. johnstoni valdemaculosa*, f. n. mihi. ♀. Nyasaland, Mt. Mlanje. April 16, 1913. *S. A. Neave.* The type specimen. Black and white. Mimic of such *Amauris* as 8.

10. *A. johnstoni confusa.* ♂ var. Kenya Colony, Dabida Mt. 4500 ft., about 100 miles W.N.W. of Mombasa. May 31, 1916. *K. St. A. Rogers.* Black and white. An important variation with a white patch in area 3 of fore-wing. Cf. Pl. XIII, fig. 9.

Plate XIV.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A. Robinson, Photo.

7/8 Natural Size.

Forms of *Acraea johnstoni* **and their models.**

R

THE BUTTERFLIES OF TRANSJORDAN

By Captain A. F. Hemming, C.B.E.

[Read 1st June, 1932.]

With Plates XV, XVI, and Three Text-figures.

PART I. INTRODUCTORY.

Up till 1920, when Transjordan passed under the political influence of Great Britain, nothing whatever was known regarding the butterflies of that country. The first entomologist to visit it was Mr. H. St. Philby, C.I.E., who in 1922 was appointed as the representative in Transjordan of the High Commissioner of Palestine. The collections made by him in that, and the following, year are now in the British Museum (Natural History). They include four new subspecies, subsequently described by Major P. P. Graves (Graves 1925). Mr. Philby's opportunities for collecting were inevitably limited, but the material he obtained justified the hope that further discoveries of interest remained to be made, whenever more extensive collecting in Transjordan should prove possible.

These hopes have been fully justified by the important collections made in 1926–1928 by Captain L. K. Lockhart, M.B.E., M.C., R.A., while serving in the Transjordan Frontier Force, and he greatly added to the value of these collections by sending with copious notes written from day to day in regard to the position of little-known localities, the relative abundance of particular species, and similar matters. His duties took him over the greater part of Transjordan and, wherever possible, he obtained specimens, making special efforts to do so in little-known areas. Some of his most interesting captures were made during brief halts while on the march in remote districts, which it is very unlikely that any entomologist will again visit for many years. I desire to take this opportunity of expressing my grateful thanks to Captain Lockhart for his indefatigable efforts to make this collection as complete as possible.

In addition, I wish to express my thanks to Lt.-Colonel F. W. Bewsher, D.S.O., O.B.E., M.C., at that time Commanding the Transjordan Frontier Force, and to Mrs. Bewsher, who have very kindly placed at my disposal the collections which they made in Transjordan during the same period.

The Emirate of Transjordan in which these collections were made is an irregularly shaped territory, bounded on the north by Syria, on the north-east by Iraq, on the east and south by Nejd and on the west by Palestine. Its boundaries are not marked on any map and can only be ascertained by reference to a number of published official papers, that are not readily accessible. The following description is therefore given in order to define the region covered by this paper. The frontier between Nejd and Transjordan starts in the north-east from the point of intersection of meridian 39° E. and parallel 32° N., which marks the termination of the frontier between Nejd and Iraq, and proceeds in a straight line to the point of intersection of meridian 37° E. and parallel 31° 30′ N. and thence along meridian 37° E. to the point of its intersection with parallel 31° 25′ N. From this point, it proceeds in a straight line to the point of intersection of meridian 38° E. and parallel 30° N., leaving all projecting edges of the

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Wadi Sirhan in Nejd territory. Thence it proceeds along meridian 38° E. to the point of its intersection with parallel 29° 35′ N. From this point, the southern frontier between Transjordan and Nejd is not yet defined, but runs in a practically straight line to a point a few miles south of the town of Aqaba at the head of the gulf of that name. The western frontier runs from a point on the shore of the Gulf of Aqaba two miles west of the town of that name northwards up the centre of the Wadi Araba, the Dead Sea, and the River Jordan to the point where that river joins the River Yarmuk and thence to El Hammie. The northern frontier between Transjordan and Syria has not yet been fully delimited on the ground and is at present the subject of discussion between the British and French Governments. Its general line is laid down by the Franco-British Convention of December 23rd 1920 (Cmd. 1195). This is defined in that Agreement as running from west to east from a point south of El Hammie on the Hedjaz Railway (where the frontiers of Palestine, Syria and Transjordan join) along a line drawn from Samakh on the Lake of Tiberias to a point south of Nasib on the Hedjaz Railway, thence along a line to Imtar south of the Jebel Druse, and thence to the Iraq frontier along a straight line towards Abu Kamal on the River Euphrates. The Transjordan–Iraq frontier is reached at a point on this line situated approximately on meridian 38° 20′ E. From this point, the Transjordan–Iraq frontier runs in a straight line to the Nejd frontier situated at the point of intersection of meridian 39° E. and parallel 32° N.

The northern part of Transjordan consists of elevated country, rising in places to between 3,500 and 4,000 feet. Here are found a number of species that occur in corresponding stations in the Lebanon. On the western frontier, there is an abrupt fall to a narrow fertile strip that borders the River Jordan. It is here that the characteristically African species occur. To the east of the elevated portion, the country slopes gradually down to the steppe country, through which the Hedjaz Railway runs. This region, in turn, merges gradually into the desert, where the butterfly fauna is extremely poor and is confined to small areas where there is water. The species found here are, in general, desert representatives of Palaearctic groups, though a few species of African affinities also occur.

The collections made in Transjordan by Mr. Philby contain representatives of 41 species, all but six of which are represented in the Lockhart collection. Captain Lockhart took 53 species and observed four others of which he was unable to obtain specimens. The Bewsher collections are smaller but contain one species (*Syntarucus pirithous*, L.) not taken either by Mr. Philby or by Captain Lockhart. The known butterfly fauna of Transjordan has been enriched by the addition of 21 species as the result of these collections. Of these, one species (*Apharitis myrmecophila*, Dum.) is new to Asia, having previously been recorded only from North Africa. In the case of a number of others, the known area of distribution is substantially enlarged by these collections. One new species and six new subspecies are represented. Paratypes have been presented to the British Museum (Natural History), and specimens of other species have been added to the Museum collections wherever their previous series was inadequate.

For the photographs which accompany this paper, I am indebted to Mr. W. H. T. Tams, for the *camera lucida* drawings of genitalia to Mrs. V. M. Hemming, and for the diagrams of wing-markings to Lt.-Colonel H. D. Peile. To all of these, I give my best thanks.

PART II. SYSTEMATIC.

Nymphalidae.

1. **Melitaea arduinna evanescens,** Staudinger.

Melitaea arduinna var. *evanescens*, Stgr., 1886, Ent. Z. Stettin, **47** : 230, " Nord Persien, Samarkand, Diabekir."

This species was not found in Transjordan by either Captain Lockhart or Colonel Bewsher. The only known Transjordan specimens (now in the British Museum) are the two ♀♀ taken by Philby on the Jebel Suwada near Es Salt on April 19th, 1923, which have been described in detail by Graves (Graves 1925). They appear to be referable to ssp. *evanescens*, Stgr., which is represented in the Museum collection from western Asia Minor (Kedos), Syria (Shar-Deresy, and Abkès) and Persia (Mungerrah Mts. and Shakuh).

2. **Melitaea phoebe dorae,** Graves.

Melitaea phoebe dorae, Graves, 1925, Trans. Ent. Soc. Lond., **1925** : 101, " Petra."

and

2a. **Melitaea phoebe telona,** Fruhstorfer.

Melitaea phoebe telona, Fruhst., 1908, Int. ent. Z. Guben, **1** : 310, " Palastina, Jerusalem."

Both the above subspecies of *phoebe* occur in Transjordan. On the basis of Philby's material now in the British Museum and of that collected by Captain Lockhart the distribution, so far as at present known, of the two subspecies in Transjordan is as follows :—

M. phoebe telona. Rusaifa, Bir Ayub Road and Wadi Sir (*Philby*); Sukhni and Kalat-ed-Debaa (*Lockhart*).

M. phoebe dorae. Petra and Kerak (*Philby*); Ain Musa 3,300 ft. (*Lockhart*).

All the specimens referred to above were taken in March and April except that from Wadi Sir, which was caught on August 14th.

3. **Melitaea didyma casta,** Kollar.

Melitaea casta, Kollar, [1849] Denkschr. K. Ak. Wiss. Wien, **1** : 52, " Sudpersien."

and

3a. **Melitaea didyma,** Esp. ssp.

This species seems to be scarce in Transjordan, where it occurs in two different subspecies, viz. :—

(a) *Melitaea didyma casta*, Koll.

Captain Lockhart only obtained one specimen, a female, which he caught at Ain Musa on March 30th, 1927. The black spots on the upperside are rather heavily marked and the abdomen is blacker than usual. This subspecies was taken by Philby on the Jebel Suwada near Es Salt (19.iv), on the Bir Ayub Road (21.iv), and in the Wadi Sir (14.viii). These specimens were referred to *deserticola*, Obth. (1876), by Graves (1925), who did not discuss *casta*, Koll. The north African subspecies and *casta* are very much alike, the former differing from *casta* mainly in the slightly more variegated ground-colour of the upperside of the ♀ and in both sexes by the greater definition of the markings on the underside.

(b) **Melitaea didyma sargon,**[*] ssp. nov.

(Pl. XV, fig. 10 ♂, 11 ♀, 12 ♀; Pl. XVI, fig. 37 ♂, 38 ♀, 39 ♀.)

Nearest to subspecies *casta*, Koll., from which it differs as follows :—

Upperside. Ground-colour reddish-brown, darker and redder than in *d. casta*; black marginal border (forewings and hindwings) reduced to a thin black line (fairly wide in *d. casta*). *Forewing.* Black spots in, and at the basal end of, discal cell greatly reduced in size and in some cases obsolete; black spots in medial and post-discal row greatly reduced in size; black submarginal spots smaller. *Hindwing.* No black markings except four (or less) black spots in the discal row and four black submarginal spots. *Underside. Forewing.* Black spots in discal cell absent or only very faintly indicated; spots in discal series smaller; the pale yellow apical patches contrast more strongly with the reddish ground-colour owing to the tone of the latter being darker than in *d. casta. Hindwing.* Yellow markings reduced in size and duller in tone; black spots smaller; outer black edging to brown spots of discal series reduced in size.

Average length of forewing : ♂ 20 mm., ♀ 23 mm.

Habitat. Iraq, Baghdad; Transjordan, Wadi Rajil.

♂ Holotype and ♀ allotype " Baghdad, *W. K. Loftus* " (B.M. Types No. Rh., 380 ♂, 381 ♀) and ♂ 5 paratypes (same data as holotype) (B.M. Types No. Rh. 382–386); and ♀ 1 " Transjordan, Wadi Rajil, N.W. of Jebel Kurma, 20.iv.1927, *L. K. Lockhart* " (A. F. Hemming, coll. No. 19785).

Captain Lockhart's specimen (Pl. XV, fig. 12 and Pl. XVI, fig. 39) is even more extreme than the ♀ allotype, there being no black markings on the upperside of the hindwing except 5 minute submarginal spots. It is very large, its forewing length being 26 mm.

The distribution so far known of *sargon* is very limited compared with that of *casta*, which is represented in the British Museum by specimens from N.W. Persia (Harir and Karind Gorge), " Mesopotamia," and Egypt (Wadi Hafa and Suez), in addition to those from Transjordan (noted above) and from Palestine.

4. **Melitaea trivia pseudodidyma,** Rebel.

Melitaea trivia pseudodidyma, Rebel, 1905, Ann. Naturh. Mus. Wien, **20** : 194, " Asia Minor : Serai Dagh bei Konia, Erdschias Gebiete (Ali Dagh) und Brussa."

This species appears to be scarce and local in Transjordan. Captain Lockhart only obtained one specimen, a male, which he caught at Kafringi on October 6th, 1927. Colonel Bewsher took a male at Amman on May 5th, 1927, and Mrs. Bewsher a pair at Zerqa on April 12th, 1928. Graves (1925) records its capture by Philby at Petra (16.iii) and Es Salt (18.iv) and on the Bir Ayub Road (21.iv).

Judging by the longer series available from Palestine, *trivia* probably has three broods in Transjordan, the first in March–April, the second, which has not yet been taken, (probably) in June–July and the third in September–October. On this hypothesis, all the specimens noted above belong to the first brood, except that taken at Kafringi, which belongs to the third. The latter specimen is noticeably smaller, the length of its forewing being only 15 mm., as compared with 18 mm. in the spring brood examples.

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[*] Named after Sargon of Kish, the founder of the Semitic empire of Agade, who became the supreme ruler in Mesopotamia.

5. **Nymphalis cardui,** Linn.

Papilio Nymphalis cardui, Linn., 1758, Syst. Nat., ed. **10** : 475, No. 107, " Sweden."

This species is, no doubt, much more widely distributed in Transjordan than the small number of specimens collected would suggest. Those sent home by Captain Lockhart were taken in 1927 between March 3rd and May 6th at Shunit Nimrin, Sukhni and Qasr Azraq.

6. **Nymphalis atalanta,** Linn.

Papilio Nymphalis atalanta, Linn., 1758, Syst. Nat., ed. **10** : 478, No. 119, " Sweden."

As in Palestine, this species is scarce in Transjordan. Captain Lockhart took one specimen in the Wadi Yabis (13.iii) and saw others at Sukhni (25.iii), Jabir and Semme (23.xi). There is a specimen in the British Museum taken by Philby at Ain Sara.

7. **Polygonia egea,** Cramer.

[*Papilio*] *egea* Cramer, 1775, Uitl. Kapellen, **1** (7) : 124, pl. 78, fig. C, D ♂, " Constantinople et Smyrne."
Papilio egea id., 1776 *ibid.,* **1** : 152.

This species was taken by Philby at Amman in August (Graves 1925). No specimens are included in the collection made by Captain Lockhart, who only once met with it—in camp near Qasr Azraq in May 1927—and unfortunately failed to catch it.

8. **Charaxes jasius,** Linn. ssp.

Papilio jasius, Linn., 1767, Syst. Nat., ed. **12**. 1 (2) Errata (*nom. nov.* pro *Papilio jason,* Linn., *l.c.* : 749, No. 26), " Barbaria."

Unfortunately, no specimen of this species was obtained, but its existence in Transjordan has been definitely established by Captain Lockhart. It was discovered by him in October 1927 when marching with a detachment of the Transjordan Frontier Force from Zerqa (Transjordan) to Samakh (Palestine). The party left Zerqa on October 4th and reached Kafringi on the evening of October 6th. The following is an extract from Captain Lockhart's diary for the following day :—

" *Oct. 7th.* Marched along south side of Wadi Kafringi, along very bad single file track. So poor that 2 baggage camels fell over the kud ! And we had trouble with leading the Hotchkiss-gun pack-ponies. The track descends steeply to Jemeime, where *Zizyphus spina-christi* was in evidence, and here the scrub oak virtually finished. Hence the presence of *T. mediterraneae* or *T. balkanica.* We emerged on to the plain of the Ghor, after leading our animals down a steep and poor goat-track for several miles. The place would be south by perhaps 1½ miles of Wadi Kafringi, where it crosses the track marked in red on the map.* I point this out because Smith and I, when mounted and just moving forward, saw a magnificent specimen of *Charaxes jasius* for the first time in this country. It was hovering round a ' cotton plant,' which is the name given to a Jordan Valley tropical-looking bush which grows great thick flat leaves like cows' ears and has green pods as large as cricket balls which burst when ripe and show themselves stuffed with white cottony fibre. I dismounted rapidly and snatched the net. The *Charaxes jasius,* however, had been frightened by the horses and made off rapidly towards the Jordan. I followed across country for a quarter of a mile at the double, keeping him well in view. Smith came after me on horseback. The butterfly eventually settled, and though I thought I marked the place well, we could not succeed in putting it up again ! A most disappointing affair, but enough to make us keep our eyes skinned for further chances. We eventually did see one more specimen, but it was travelling in the wind and showed no signs of settling. That was about 2 miles south of Wadi Yabis. . . ."

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* The map referred to is " Syria, Jaffa–Damascus " issued by the Geographical Section General Staff, No. 2321.

At my request, Mr. N. D. Riley kindly consulted one of his colleagues in the Botanical Department of the British Museum (Natural History), who, while unable to identify Captain Lockhart's " cotton plant " with certainty, thought that it was probably *Calotropis procera*, Ait. (Asclepiadaceae).

SATYRIDAE.

9. **Pararge megera iranica,** Riley.

Pararge megaera iranica, Riley, 1921, Ann. Mag. Nat. Hist., (9) **8** : 592, " Kizil-Robat, Mesopotamia ; Karind Gorge and Harir, N.W. Persia."

Neither Captain Lockhart nor Colonel Bewsher found this species in Transjordan. The only locality in which it is known to occur is Petra, where Philby took some worn specimens (now in the British Museum) in March 1923. This species which is very rare in Palestine (Graves 1925 and Hemming 1927) is, no doubt, also very scarce in Transjordan.

Graves (1925) tentatively assigned the Petra specimens to ssp. *iranica*, Riley, and after examining them I am of the same opinion.

10. **Agapetes titea palaestinensis,** Staudinger.

Melanargia titea var. *palaestinensis*, Stgr., 1901, Cat. Lep., ed. **3** : 42, No. 254 C, " Palestine ; Lebanon (*trans.*)."

This species which is widely distributed in Palestine appears to be local in Transjordan. It was first taken by Colonel Bewsher at Amman, where it was very plentiful (9–19.v.1927). Captain Lockhart found it in the Wadi Shaib (28.iv.1928) and at Zerqa (5.v.1928). Philby took one specimen at Jerash (20.v).

The Transjordan specimens do not differ from those taken in Palestine.

11. **Eumenis anthe,** Hoffmansegg.

Papilio anthe, Hoffmansegg, nom. nov. pro *P. persephone*, Hb. (figs. 589, 590); 1806, Mag. f. Insektenk. (Illiger), **5** : 182, " Sud-Russland."

Papilio persephone*, Hb., 1805, Samml. europ. Schmett., **1 : 21, No. 2, pl. 115, fig. 589, 590 ♀, " Sarepta."

This species, which is new to Transjordan, was first taken by Captain Lockhart in 1927 on May 22nd in a salt marsh near Qasr Azraq. He subsequently took it in camp at Qasr Azraq (31.v), in a bushy patch of ground 6½ miles S. of Qasr Azraq (3.vi), at Habeibe (10 & 11.vi) and at Zerqa (4.ix). The last date is extraordinarily late, but it is highly unlikely that the specimens in question represent even a partial second brood. There is little doubt that they are belated individuals which failed to emerge before the end of the normal period of emergence, owing probably to the larvae not having had time to pupate before the summer diapause. In all, 12 specimens were taken, 4 ♂♂ and 8 ♀♀. Of the females, 4 were of the (typical) white form and 4 of the yellow form (*hanifa*, H.-S., 1850 = *hanifa*, Nordm. 1851).

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* This name is invalid as it is a primary homonym of *Papilio persiphone*, Fab. 1793.

12. **Eumenis thelephassa,** Hubner.

Eumenis thelephassa, Hubner (*c.* 1819–1826), Samml. exot. Schmett., **2** [no text], Tab. *Eumenis,* fig. 1, 2 ♂, 3, 4 ♀.

This species was taken by Captain Lockhart at Umm Jamal, Qoseir Halibat, Zerqa and Jerash. Colonel Bewsher found it in abundance at Amman (9.v.1927); and Philby took one specimen on the Jebel Suada. The earliest date on which it was taken was April 22nd (Zerqa) and from about that date the species appears to be on the wing till July. In addition, Captain Lockhart took in 1927 a number of specimens very late in the season, *e.g.* at Zerqa (30.ix) and Jerash (5.x). These are very late dates, but there is little doubt that, as in the case of the specimens of *E. anthe*, Hffsg., referred to above, they represent only laggards from the May emergence.

13. **Eumenis fatua sichaea,** Lederer.

Satyrus statilinus var. *sichaea,* Lederer, 1857, Wien ent. Monats., **1** : 91, " Beirut."

This species, which is new to Transjordan, was discovered on July 29th, 1927, by Captain Lockhart. The specimens taken were flying round pine trees near Tel-Abu-Hajal (2 miles S. of Jerash) at an elevation of 1,800 ft. In the same year, he took this species at Jerash (5.x) and at Kafringi, on the Jebel Umm-ed-Daraj (where it was plentiful), and N.W. of Devi-el-Liye (6.x). Later in the same month, (19.x) Colonel Bewsher took it at Jerash. As in the case of *E. anthe*, Hffsg., there is little doubt that these specimens taken in October are merely belated individuals of a single annual brood.

14. **Eumenis pisidice,** Klug.

Hipparchia pisidice, Klug, 1832, in Ehrenberg, Symb. Phys. Ins., **3**, Signature K : ², pl. 29, fig. 9, 10 ♂, " *Habitat in Montis Sinai regionibus superioribus.*"

This species which is new to Transjordan was found by Captain Lockhart on the Jebel Umm-ed-Daraj on October 6th, 1927.

15. **Maniola telmessia,** Zeller.

Hipparchia telmessia, Zell., 1847, Isis (Oken), **1847** : 4, " Rhodus, Mermeriza, Macri."

This is another species not previously recorded from Transjordan. Captain Lockhart first took it, in company with *E. fatua sichaea* on July 29th, 1927, near Tel-Abu-Hajal. Later, he found it at Zerqa (4.x), Jerash (5.x) and Kafringi (6.x). All the specimens taken in October were females which were no doubt laggards from the July emergence that had reappeared after aestivation. I cannot see any material difference between *telmessia* from Transjordan and Palestine and nominotypical *telmessia* from Anatolia.

16. **Maniola lupinus centralis,** Riley.

Epinephele lupinus centralis, Riley, 1921, Ann. Mag. Nat. Hist., (9) **8** : 594, " Mesopotamia (types from Kizil-Robat, L. bank of R. Dyala), Kurdistan, and Western Persia."

This species was discovered in Transjordan by Philby (19.v.1923), who took a single ♀ at Jerash. In 1927 Colonel Bewsher took a freshly-emerged specimen at Amman on May 9th. In the same year, Captain Lockhart found the species at Zerqa (4 & 25.ix) and Sukhni (plentiful on 9.ix), in the hills N.W. of Amman at an elevation of 3,000 ft., and at Salt (10.ix).

Transjordan *lupinus* are not separable from the subspecies from Iraq and Persia which Riley has named *entrali* and of which I have specimens in my collection, given me by Colonel Peile, by whom they were taken at Harir in N.W. Persia. A ♀ taken by Captain Lockhart (20.vii.1927) in the Lebanon at Anger (2,500 ft.) is also referable to this subspecies. The females of *entrali* are very dark brown on the upperside and the orange scaling is dark in shade and very restricted in area. On the underside, the central band on the hindwings is only very faintly indicated, the wings being substantially unicolorous.

17. **Ypthima asterope,** Klug.

Hipparchia asterope, Klug, 1832, in Ehrenberg, Symb. Phys. Ins., **3**, Signature K : 2, pl. 29, fig. 11, 12 ♂, 13, 14 ♀, " *Syria, Arabia felix, Arabia deserta.*"

This species was taken by Captain Lockhart at Shunit Nimrin, Sukhni, Zerqa, Jerash and Jemeime. Philby found it at Petra. As in Palestine, *asterope* can be found on the wing in Transjordan during the greater part of the year, *e.g.* at Shunit Nimrin, where the earliest and latest dates were respectively 17.iii and 11.xi.

DANAIDAE.

18. **Danaida chrysippus,** Linn.

Papilio Danais chrysippus, Linn., 1758, Syst. Nat., ed. **10** : 471, No. 81, " *Habitat in Aegypto.*"

This species, though widely distributed in Palestine, appears to be scarce in Transjordan, from which it has not previously been recorded. Captain Lockhart took it near the Allenby Bridge, at Sukhni, Zerqa, and Jemeime. The earliest date on which it was taken was July 15th (Allenby Bridge) and the latest October 21st (Sukhni).

LYCAENIDAE.

19. **Lampides boeticus,** Linn.

Papilio Plebius boeticus, Linn., 1767, Syst. Nat., ed. **12**. 1 (2) : 789, No. 226, " Barbaria."

This species appears to be surprisingly scarce in Transjordan. Captain Lockhart only took it at Sukhni (31.v, 22.vi and 9.ix), Zerqa (13.vii and 25.ix) and Jerash (5.x). Mrs. Bewsher found it at Petra (10.iv).

20. **Syntarucus pirithous telicanus,** Lang.

Papilio Plebius pirithous, Linn., 1767, Syst. Nat., ed. **12**. 1 (2) : 790, No. 235, " Habitat Algiriae."
Papilio telicanus, Lang, 1789, Verz. Schmett., ed. **2** : 47, " Sudlich. Frankreich."

The only specimen received from Transjordan is a small ♂ taken by Colonel Bewsher at Sukhni (21.x.1927). The species had not previously been recorded from Transjordan.

There is no doubt that it was this species that Linnaeus named *Papilio pirithous* in 1767, from specimens received from Algeria. This name must, therefore, be adopted for the African and Spanish subspecies. Lang's name *telicanus* based on specimens from the south of France may, however, be retained for the subspecies found in France, Italy and further east in Europe.

21. **Azanus jesous gamra,** Lederer.

Lycaena gamra, Led., 1855, Verh. zool.-bot. Ver. Wien, **5** : 189, pl. 1 (Led.), fig. 3 ♂, " Beirut and Senaar."

This species which is new to Transjordan was only once found by Captain Lockhart at a place 5 miles south of Jerash, where he caught two males on July 29th, 1927.

22. **Tarucus balkanica,** Freyer. (Fig. 1.)

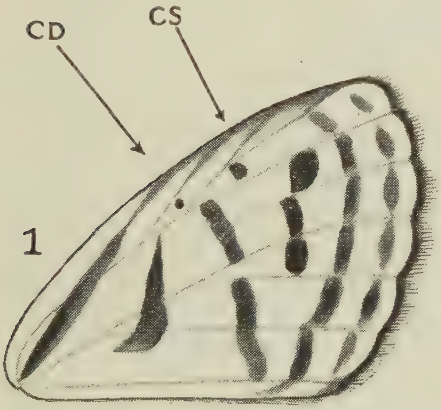
Lycaena balkanica, Frr., 1844, Neuere Beitr. Schmett., **5,** (71) : 63, pl. 421, fig. 1 ♂, 2 ♀, " Turkei."

This widely-distributed species has not previously been recorded from Transjordan where it is very local. It was taken at Jemeime (7.x), Zerqa (4.v), Shunit Nimrin (17.iii), 5 miles S. of Jerash (29.vii) and Qasr Azraq (7.v).

23. **Tarucus mediterraneae,** Bethune-Baker. (Fig. 2.)

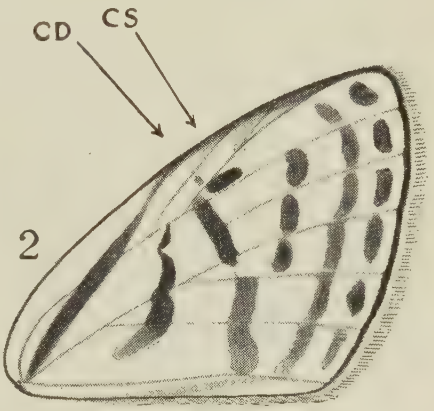
Tarucus mediterraneae, B.-Baker, May 1918, Trans. Ent. Soc. Lond., **1917** : 281, pl. 14, fig. 7, 7A ♂, 7B ♀, " Egypt (types from Alexandria), Algeria, Palestine."

This species also appears to be very local. The only localities where it was taken were near the Allenby Bridge (3.iii) and at Shunit Nimrin (17.iii and 11.xi) and Jemeime (7.x). Graves (1925) records it from Aqaba.



× 4.

♂ forewing, underside.



× 4.

♂ forewing, underside.

Fig. 1.—*Tarucus balkanica,* Frr. " Palestine, Beisan, 100 ft., 14.v.1923, *L. K. Lockhart.*"
Fig. 2.—*T. mediterraneae,* B.-B. " Egypt, Aswan, 6.vi.1921, *K. J. Hayward.*"

As the superficial differences between this and the preceding species are not very conspicuous it may be useful to add the following short note of the characters by which the two species can be separated. Of these, the most reliable is the shape of the spot (the " critical spot ") in Interspace 6 and the position in relation to it of the minute black dot (the " critical dot ") in Interspace 9 on the underside of the forewings :—

♂ *Upperside.* In *balkanica* there is a discal series of 4 (or 5), often rather indistinct, black spots. In *mediterraneae* these spots are absent.

♀ *Upperside.* In *balkanica,* the ground-colour is usually more or less uniformly blackish-brown, faintly scaled with dull blue in Interspaces 1B, 1 and 2, the white inter-neural scaling on forewings and hindwings absent or only faintly indicated. In *mediterraneae*, these white dashes are usually very clearly marked and the blue scaling on the forewing is more brilliant and more extensive. (Occasionally females of the two species occur, intermediate in character as regards the points noted above. These can, however, readily be separated by reference to the underside.)

♂♀ *Underside.* In *balkanica* the " critical spot " (see above) on the forewing (see fig. 1) is small, more or less circular in shape, and well separated from the " critical dot," detached from the other spots. In *mediterraneae*, the critical spot (fig. 2) forms a relatively long straight line parallel to the costal margin. It is situated close both to the black line which runs up towards that margin through the end of discoidal cell, and to the " critical dot."

Other points of difference on the underside are: (1) the streak in Interspace 1a is in *balkanica* short and nearer the distal termen than the base of the wing, while in *mediterraneae* it is three times as long and has its origin at a point situated at about the centre of the Interspace; (2) the three discal spots are less symmetrical in size and position in *balkanica* than in *mediterraneae*; (3) the submarginal spots are almost joined in *balkanica*, but are well separated in *mediterraneae*; (4) the black streak that runs across the middle of the cell is shaped like a spear-head in *balkanica*, while in *mediterraneae* its sides are deeply indented. In addition, in *balkanica*, the fringe is deeply scalloped, but in *mediterraneae* hardly at all.

24. **Zizeeria karsandra,** Moore.

Polyommatus karsandra, Moore, 1865, Proc. Zool. Soc., **1865** : 505, pl. 31, fig. 7, " Plains of N.W. India, from Oudh to the Punjab."

Though very widely distributed in Palestine, this species is local in Transjordan, though plentiful where it occurs. It was taken by Captain Lockhart at Sukhni, Zerqa, Jerash, Kafringi, Jemeime and Petra.

Odd specimens were found freshly emerged early in the year, *e.g.* at Zerqa on March 24th and Sukhni on March 27th. A few specimens were taken in May, the species occurring in larger numbers in June, and early July. No specimens were found again until September when the main emergence takes place, the species continuing to be plentiful until towards the end of October.

25. **Chilades galba,** Lederer.

Lycaena galba, Led., 1855, Verh. zool.-bot. Ver. Wien, **5** : 190, pl. (Led.) 1, fig. 4 ♂, " Beirut and Senaar."

This species, which appears to be widely distributed, was taken by Captain Lockhart between the Allenby Bridge and Shunit Nimrin (3.iii and 15.vii), at Zerqa (14.iii and 24.vi), Sukhni (22.vi), Qasr Azraq (22.v and 7.vi) and 5 miles S. of Jerash (29.vii). Philby took it at Azraq in 1923 as late as October 7th (Graves 1925).

26. **Chilades trochylus,** Freyer.

Lycaena trochylus, Frr., 1845, Neuere Beitr. Schmett., **5** (74) : 98, pl. 440, fig. 1 ♂, " In der europaischen Turkei."

This species was taken by Captain Lockhart in 1927 at Jerash (29.vii) and Kafringi (6.x). Graves records its capture by Philby in the Wadi Sir (13.viii), at Fuhais (14.viii) and Azraq (7.x). His record of its capture by Captain Lockhart at Amman is based on some misunderstanding. The October specimens probably represent a second brood.

27. **Plebeius pylaon philbyi**, Graves.

(Pl. XV, fig. 6 ♂, 7 ♀; Pl. XVI, fig. 33 ♂, 34 ♀.)

Plebeius sephyrus philbyi, Graves, 1925, Trans. Ent. Soc. Lond., **1925** : 55, pl. 5, fig. 1 ♂, 2 ♀, "Petra."

This insect was originally described as a subspecies of *P. sephirus*, Friv., but in the light of the much larger amount of material now available, taken by Captain Lockhart and Colonel Bewsher, it should be regarded as a southern subspecies of *pylaon*, F. de W. This view is supported by the evidence of the genitalia, and by the appearance of the insect itself. That it is much nearer to *pylaon* than to *sephirus* is shown by its constantly smaller size, by the ground-colour and the relatively large size of the submedian spots on the underside in both sexes, and, in the male on the upperside, by the very narrow black submarginal border.

Similar considerations point also to *hespericus*, Ramb., (1840) (hitherto regarded as a subspecies of *sephirus*, Friv.) being a subspecies of *pylaon*. That species has, therefore, a distribution strikingly similar to that of *Zegris eupheme*, Esp., [1805] which also occurs in Spain, South Russia, Syria, Palestine and Transjordan.

This species was taken in 1927 by Captain Lockhart and Colonel Bewsher in the desert, 25 miles east of Zerqa between 11th and 15th April. On the last-named date, it was by far the most plentiful of the few species found, 54 examples (♂♂ 47, ♀♀ 7) being taken. A few specimens were taken between 23rd and 29th April in the immediate neighbourhood (1–1½ miles W. and 1½ miles S.W.) of Qasr Azraq, but by the latter date the emergence was nearly over. Two worn ♂♂ were taken at Qasr Amruh on May 7th. In 1928, Mrs. Bewsher took a fresh pair of this species at Petra, where Graves' types were caught by Philby.

In describing *philbyi*, Graves distinguished two types of ♀, which he designated forms A and B respectively. Form A which he figured (pl. 5, fig. 2) had a forewing length of 17 mm. and had a deep clear brown ground-colour extensively suffused with blue scales. Form B was smaller (forewing length 13·9 mm.) and had only a very slight blue scaling at the bases of the wings. (The ♀ in my collection from Khweilfa, also mentioned by Graves, is not referable to *philbyi* and belongs, probably, to an undescribed subspecies of the true *sephirus* of Frivaldsky or to a new species.) With only two specimens at his disposal, Graves did not designate either form A or form B as typical. The material now available shows clearly that form B is the normal ♀ of *philbyi*, form A being only a blue dimorphic form, transitions to which are represented in the present collection.

28. **Aricia agestis calida**, Bellier.*

Lycaena agestis var. *calida*, Bellier, 1862, Ann. Soc. ent. France, (4) **2** : 615, pl. 14, fig. 6 ♀, "Corse."

This species was discovered in Transjordan by Captain Lockhart who, in 1928, took one ♀ at Zerqa (31.v) and one ♂ at Sukhni (22.vi).

In these specimens the orange lunules are well developed and the ground-colour of the underside is bright reddish-brown. In view of these characters I refer these specimens to *calida*, but it is possible that when more material is available, it may be found that Transjordan *agestis* are separable from Corsican *agestis*.

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* The older name for this species *Papilio medon*, Hufnagel, 1766, is invalid as it is a primary homonym of *Papilio medon*, Linn., 1763. I have therefore adopted Schiffermuller's name *agestis*, the description of which, though short, is quite recognisable.

This species is, no doubt, scarce in Transjordan, as also in Palestine.

29. **Polyommatus loewii lockharti,** Hemming.

(Pl. XV, fig. 1 ♂, 2 ♀, 3 ♀ (f. *margaritae*); Pl. XVI, fig. 28 ♂, 29 ♀, 30 ♀ (f. *margaritae*).)

Polyommatus loewii lockharti, Hemming, 1929, Proc. Ent. Soc. Lond., **4** : 3. "Qasr Azraq" and ♀-form *margaritae* Hemming, *l.c.* : 4.

This is a very well-marked subspecies, the whitish post-discal inter-neural streaks on the upperside in the females being very striking. About 1 in 5 of the ♀♀ are blue (form *margaritae*, Hem.).

Captain Lockhart, who only met this species in 1927, took it first in the Wadi Rajil (20.iv). Between April 24th and May 6th he and Colonel Bewsher found it in a number of localities in the immediate neighbourhood of Qasr Azraq. On April 26th, Captain Lockhart found it 2 miles E. of Qasr Weineid, and on May 7th, 3 miles E. of Qasr Amruh. It was extremely local, being confined to small patches in wadis where there was vegetation. In such localities it was plentiful. The combined series of Captain Lockhart and Colonel Bewsher contain 79 ♂♂ and 31 ♀♀.

I take this opportunity to figure the types (Pl. XV, fig. 4 ♂, 5 ♀; Pl. XVI, fig. 31 ♂, 32 ♀) of the subspecies of *loewii* discovered by Captain Lockhart at Baalbek in the Anti-Lebanon, which I have named *Polyommatus loewii antilibanotica* (Hemming, 1929, *Proc. Ent. Soc. Lond.*, **4** : 4). This subspecies is characterised by its large size (length of forewing ♂ 17 mm., ♀ 16 mm.), by the clear bright blue of the male upperside, and the very wide orange submarginal lunules of the female upperside (this latter characteristic is, unfortunately, not very clearly shown in the photographic reproduction on Pl. XV, fig. 5). This subspecies has recently been re-described by Pfeiffer (1932, *Mitt. münchen. ent. Ges.*, **22** : 41, pl. 3, fig. 15 ♂ type, 17 ♀ type, 18 ♀ paratype) as *Lycaena löwii germaniciae* from specimens taken at Marasch in Turkish north Syria. The distinguishing characters given in his description are the same as those which mark *antilibanotica*, to which therefore *germaniciae* should be sunk as a synonym.

30. **Polyommatus icarus lucia,** Culot.

Lycaena icarus var. *an* ab. *lucia*, Culot, 1905, Bull. Soc. lep. Genève, **1**, (1) : 68, pl. 1, fig. 6, 8 ♂, 7 ♀, "Syrie."

Lycaena icarus var. *lucetta*, Culot, 1909, *l.c.* **1**, (4) : *Errata* nom. nov. pro *lucia*, Culot.*

As was to be expected, this species is widely distributed and plentiful in Transjordan except in the purely desert region. It was found at Shunit Nimrin, Zerqa, Sukhni, Wadi Musa, Jerash, Kafringi and Jemeime. In the desert region, one specimen only was taken (Wadi, 12 miles N.W. of Qasr Azraq).

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* In 1909, Culot proposed the name *lucetta* as a *nom. nov.* for *lucia*, Culot, on the ground that that name was pre-occupied. This is not so. His *Lycaena icarus* var. *lucia* is not a primary homonym of *Polyommatus lucia*, Kirby (1837), as in their original descriptions the two names were attributed to different genera (i.e. *Lycaena* and *Polyommatus*). Nor is his *lucia* a secondary homonym of *lucia*, Kirby, since *lucia*, Culot, in fact, belongs to the genus *Polyommatus*, while *lucia*, Kirby, belongs to the genus *Lycaenopsis*. Culot's *lucetta* should therefore be sunk as a synonym of his *lucia* which is perfectly valid.

The first brood, which begins to emerge in mid-March (*e.g.* Zerqa 14.iii), lasts until June. The stunted second brood appears in July and lasts until October or even November (*e.g.* Shunit Nimrin, 11.xi). It is possible that these very late specimens belong to a partial third brood, but it is more probable that they belong to the second half of the second brood, the emergence of which has been delayed by the summer diapause.

Culot's description of *lucia* is not very satisfactory, as it is clearly based on small examples taken in the summer months. A long series in my collection taken by Captain Lockhart in July at Shtora and Anger in the Lebanon do, however, show the characters cited by Culot. The specimens are small and, on the underside, the ground-colour in the ♂♂ is pale pearly-grey and in the ♀♀ pale yellowish-brown, the submarginal orange lunules on this surface being very conspicuous in both sexes owing to the pale ground-colour. There is little or no blue scaling at the base of the wings on the underside. Culot was, however, wrong in supposing that the small size is characteristic of Lebanese *icarus*, it being in reality only a characteristic of the summer brood. The spring brood is as large as south European (*e.g.* south French) *icarus*, and the base of the wings on the underside is fairly strongly powdered with blue scaling. The real differences between the Lebanese and other subspecies of *icarus* are to be seen in the pale ground-colour and the greater brilliance of the submarginal lunules on the underside of the wings in both sexes. These characters are well brought out in Culot's description of *lucia*, which should be adopted as the subspecific name of the *icarus* of the Lebanon. This subspecies, which is not confined to the Lebanon, occurs throughout Palestine and Transjordan.

31. **Philotes abencerragus nabataeus,** Graves.

(Pl. XV, fig. 16 ♂, 17 ♀; Pl. XVI, fig. 43 ♂, 44 ♀.)

Turania baton nabataeus, Graves, 1925, Trans. Ent. Soc. Lond., **1925** : 62, pl. 5, fig. 5 ♂, "Petra."

This species was found in company with *P. loewii lockharti*, i.e. in the desert 25 miles E. of Zerqa at Qasr Weineid, in the immediate neighbourhood (to the N.E. and the S.W.) of Qasr Azraq, and at a locality 3 miles E. of Qasr Amruh. All these captures were made in 1927 within the period April 13th and May 5th. Most of the specimens taken were females. Of the males, a number were rather worn. It is probable therefore that the main emergence takes place at the end of March and the beginning of April.

I have shown (Hemming 1929) that this species is quite distinct from *P. hylactor*, Berg. (1779) [= *baton* Bergst. (1779)]. So far, *abencerragus* is the only species of this genus that has been found in Transjordan, although the closely-allied *P. vicrama*, Moore (1865), is widely distributed west of the Jordan in Palestine.

In 1929 I placed this species in the genus *Turanana*, Bethune-Baker (1916), but having now examined the genitalia of the group of allied North American species, I am satisfied that it should be referred to the genus *Philotes*, Scudder, of which the type is *P. sonorensis*, Feld. (1865).

32. **Lycaena thersamon omphale,** Klug.

Lycaena omphale, Klug, 1834, in Ehrenberg, Symb. Phys. Ins., **4**, signature K:^{4}, pl. 40, fig. 12 ♂, 13, 14 ♀, "Syria."

This species is widely distributed in Transjordan and was taken in the following localities :—Sukhni, Wadi Musa, Mafrak Station, Habeibe, N.W. of

Qasr Azraq, 5 miles S. of Jerash, Zerqa, 2 miles N.W. of Devi-el-Liye, Kafringi, Jemeime and Petra.

As in Palestine, *thersamon* can be taken in Transjordan in most months of the year, the earliest records being Sukhni (27.iii) and Zerqa (24.iii) and the latest Kafringi (6.x) and Jemeime (7.x). The species is certainly double-brooded, the examples taken early in the year being markedly larger, more brilliantly coloured, and with shorter tails than those taken in the summer and autumn.

Klug described his *omphale* from Syria and the longer tails to the hindwings of the specimens taken in Syria and other southern localities are usually relied upon as the character distinguishing *omphale* from nominotypical *thersamon*, Esper, from Sarepta. In general, this character and the duller tint of copper of the ground-colour of the upperside of both sexes are fairly reliable guides for separating *thersamon* from southern localities from *thersamon* from northern localities.

33. **Lycaena phlaeas timeus,** Cramer.

Papilio Plebeius Ruralis timeus, Cramer, 1777, Uitl. Kapellen, **2**, (16) : 137, pl. 186, fig. E, F ♀, " Smyrne."

This is another widely-distributed species in Transjordan and was taken at Zerqa, Shunit Nimrin, Sukhni, Wadi Musa, Habeibe and 5 miles S. of Jerash.

Early spring examples, *e.g.* those taken at Shunit Nimrin (3.iii) and Zerqa (25.iii) belong to the " constant " brood and are substantially the same as spring-brood *phlaeas* from central Europe. In the summer, the large majority of individuals taken show a high degree of melanic suffusion on the upperside and are referable to ssp. *timeus*, Cram. Originally described from specimens taken at Smyrna, this is the predominant subspecies in the Middle-East, *e.g.* in Asia Minor, Syria, Palestine and Transjordan.

34. **Apharitis acamas egyptiaca,** Riley.

Apharitis acamas egyptiaca, Riley, 1925, Nov. Zool. Tring, **32** : 88, Egypt (Mokattam Hills) and Palestine (Ludd).

This species which has not previously been recorded from Transjordan appears to be very scarce. It was only twice found by Captain Lockhart, once 3 miles E. of Qasr Amruh (7.v.1927) and once at Sukhni (22.vi.1928). It was also taken by Philby at Ain Hesban.

The specimens referred to above are referable to ssp. *egyptiaca*, Riley. The ground-colour is a more vivid ochreous than in *acamas acamas* and the black markings are reduced in size and are more sharply defined, thus contrasting much more vividly with the ground-colour.

35. **Apharitis myrmecophila,** Dumont.

(Pl. XV, fig. 26 ♂, 27 ♀; Pl. XVI, fig. 53 ♂, 54 ♀.)

Cigaritis myrmecophila, Dumont, 1922, Bull. Soc. ent. France, **1922** : 217, " Tunisie, dunes de Tozeur-Nefta."

This is quite the most unexpected of the discoveries made by Captain Lockhart in Transjordan, since this species had never previously been taken in Asia or, indeed, anywhere other than in the type locality, viz. Tozeur-Nefta in Tunisia.

All the specimens were taken in N.E. Transjordan in 1927. The first, a freshly emerged ♀, was taken by Captain Lockhart 2 miles E. of Qasr Weineid on April 26th. On April 30th, a second specimen, a ♂, was taken at Qasr Azraq by Colonel Bewsher. On June 5th, Captain Lockhart took a freshly emerged ♂ and ♀ 1¼ miles S. of Qasr Azraq. Finally, on July 2nd, he again took this species, this time at Hazim, 35 miles S.E. of Qasr Azraq. On this occasion, the species was moderately plentiful, as though it was difficult to catch he succeeded in obtaining 11 ♂♂ and 4 ♀♀. The females were freshly emerged, but some of the males were worn. It is possible that these July specimens represent a second brood. Captain Lockhart's specimens do not differ much from nominotypical *myrmecophila* of which there are ♂ 1, ♀ 2 paratypes (Tozeur, bred *ex larva* 28.vi.1919–2.vii.1919) in the British Museum, except that they are materially larger. This may, however, be due to the fact that the latter are bred specimens. Further material taken in the field is required before it is possible to say definitely whether the African and Transjordan races are the same; but I anticipate that they are. The bred specimens from Tozeur have a forewing length of 11 mm. in the ♂♂ and 10 mm. in the ♀♀ as compared with an average length of 13 mm. in the ♂♂ and 14 mm. in the ♀♀ in the Transjordan specimens.

Since Captain Lockhart found this species in Transjordan it has once again been taken in Asia, Captain Bertram Thomas having taken one specimen in S.E. Arabia. This was caught in the Rub' al Khali at Shena (elev. 1000 ft.) on January 5th, 1931. It is even larger than the Transjordan specimens, having a forewing length of 16 mm.

PIERIDAE.

36. **Belenois aurota,** Fabricius.

Papilio D.C. aurota, Fabr., 1793, Ent. Syst., **3**, (1) : 197, No. 614, " Coromandel."
Papilio D.C. mesentina, Cramer, 1780, Uitl. Kapellen, **3**, (23) : 140, 175, pl. 270, fig. A, B ♂, " Côte de Coromandel."

This migratory species which does not appear to have been previously taken in Transjordan was found by Captain Lockhart at Shunit Nimrin (11.xi), Sukhni (9.ix) and Zerqa (30.ix and 4.x) and near Jemeime (7.x). It is probable that in Transjordan there is only one brood, emerging in September and continuing till November.

Cramer's well-known name for this species is invalid since his *Papilio mesentina* 1780 is a primary homonym of the Nymphaline species described under the same name by him in 1777 (Uitl. Kapellen, 2 (14) : 102). Fabricius in his description of *aurota* gives a reference to Cramer's plate of *mesentina* (pl. 270).

37. **Aporia crataegi augustior,** Graves.

Aporia crataegi augustior, Graves, 1925, Trans. Ent. Soc. Lond., **1925** : 74, pl. 5, fig. 10 ♂, " Salt."

This species which is presumably very local in Transjordan was not taken either by Captain Lockhart or by Colonel Bewsher.

Graves' type material (all males) was taken by Philby at Es Salt and in the neighbourhood of Amman (on the Bir Ayub road and in the Jubaiha region).

This is a very well-marked subspecies differing from *augusta*, Turati, by the great increase in the black scaling at the marginal extremities of the veins.

38. **Pieris brassicae verna,** Zeller.

Pieris brassicae, L. var. *verna,* Zeller, 1847, Isis (Oken), **1847** : 220, "Messina."
Pieris brassicae, L. var. *aestiva,* Zeller, 1847, *ibid.*, **1847** : 220, "Syracuse."

This species appears to be scarce in Transjordan. Captain Lockhart only took it at Sukhni and Mafrak. It was taken by Philby at Amman. Where it occurs it has apparently a long flight period since the Sukhni specimen (which was worn) was taken on March 25th and the Mafrak specimen (which was freshly emerged) on November 24th.

The Transjordanian and Palestinian subspecies of *brassicae* is not distinguishable from that found on the Mediterranean coast in western Europe.

39. **Pieris rapae leucosoma,** Schawerda.

Pieris rapae var. *leucosoma,* Schawerda, 1905, Verh. zool.-bot. Ges. Wien, **55** : 516, "Syrien, Beirut."

This species was taken by Captain Lockhart at Amman, Shunit Nimrin, Allenby Bridge, Wadi Yabis, Sukhni, Zerqa and Petra. It is on the wing practically the whole of the year, the earliest date on which it was taken being March 3rd (Shunit Nimrin) and the latest, November 11th (Shunit Nimrin). The first brood is found in March–April, the second begins to emerge in May and extends to July and August. The specimens taken in the period September–November almost certainly represent a third brood.

40. **Pontia glauconome,** Klug.

Pontia glauconome, Klug, 1829, in Ehrenberg, Symb. Phys. Ins., **1**, Signature H:¹, pl. 7, fig. 18, 19 ♂, "*Habitat in Arabia deserta, in Monte Sinai.*"

This scarce species, which had not previously been taken in Transjordan, was discovered by Captain Lockhart in 1927 at Qasr Azraq, where, on April 24th, he took two males and one female about 1½ miles W. of the settlement and another male on May 5th. Captain Lockhart recognised the species immediately he took it, but in spite of careful search, he failed to find any other specimens while at Qasr Azraq. The capture of this species in Transjordan is of special interest, since it extends considerably the N.W. limits of the known area of its distribution.

41. **Pontia daplidice persica,** Bienert.

Pieris daplidice, L. var. *persica,* Bienert, 1870, Lepidopt. Ergebn. Persien : 26, "Persien, Meschcket und Charlug."
Pieris daplidice laenas, Fruhst., 1908, Ent. Z. Frankfurt, **22** : 51, "Palastina."

and

41a. **Pontia daplidice albidice,** Oberthur.

(Pl. XV, fig. 13 ♂; Pl. XVI, fig. 40 ♂.)

Pieris daplidice, L. var. *albidice,* Oberthur, 1881, Et. Ent. **4** : 47, "Algérie"; *id.*, 1888, *ibid.* : 6, pl. 5, fig. 12 ♂, "Oran, Lambèze, Biskra."

In Transjordan, the first brood is on the wing in April and May, and the second in June, July and early August. Specimens taken later in the year which probably represent a third brood (*e.g.* Amman 30.viii, Jerash 5.x) are much larger than those taken in the summer, being in every way nearer to the specimens of the April–May emergence. In favourable seasons, the species is really continuously-brooded, *e.g.* specimens of the (so-called) third brood were taken in

Palestine by Captain Lockhart and Colonel Bewsher throughout December and January. Worn specimens of what is presumably the same brood were taken in Transjordan by Captain Lockhart near the Allenby Bridge (3.iii) and at Shunit Nimrin (17.iii).

From the evidence afforded by the Linnean specimens it may be taken that the nominotypical subspecies is that found in Southern Europe and not that found in North Africa. In many ways, *daplidice* from the Near East is like that from N. Africa, but usually only a relatively small proportion of specimens show to the full the extreme characters of *albidice*, the majority corresponding to *persica*, Bienert. In some localities in Syria, *e.g.* at Beirut (Graves 1925), *albidice* is the prevailing form. Similarly in Palestine the specimens now in my collection taken by Captain Lockhart in July and August at Ludd, Beth-Shemmen and Hedida (but not at Tulkeram as inadvertently stated by Graves 1925), are strongly characterised *albidice*, although the specimens taken by him in many other localities in Palestine are *persica*. In Transjordan, there is the same range of variation. Excluding the early spring examples, the usual form is *persica*, but in some localities only an exaggerated *albidice* is found.

Turning to the question of nomenclature two courses are open. It is possible to treat (as does Graves 1925) both *persica* and *albidice* as seasonal forms, *i.e.* to assume that the subspecies in the area in question is *d. daplidice* modified seasonally into the forms named above. The variation in this species offers a close analogy to that seen in *Lycaena phlaeas*, Linn. In that species, the first brood, the "constant brood," is substantially the same over a large part of its area of distribution and it is in the summer brood that the racial characters are found. In *daplidice* also the first brood is the "constant brood" and it is the later broods that vary subspecifically. I think it best, therefore, to refer the Middle Eastern *daplidice* to subspecies *persica*, Bien., the oldest name for any form of this species from this region. Of this *laenas*, Fruhst. (1908), from Palestine is a synonym. The north African *albidice* is a good subspecies occurring also, as explained above, in isolated communities in Syria, Palestine, and Transjordan where the local conditions are favourable for its development.

In Transjordan, the subspecies usually found is *persica*, *albidice* only occurring in the desert region east of Zerqa. The following are the localities in which the two subspecies were found by Captain Lockhart :—

> ssp. *persica*, Bien. :—Amman, Allenby Bridge, Shunit Nimrin, Sukhni, Umm Jamal, Qoseir Halibat, Jerash, Kafringi, Zerqa, and Petra.
>
> ssp. *albidice*, Oberthur :—Wadi Rajil, Jebel Kurma, Qasr Azraq and neighbourhood, Qasr Amruh, Habeibe, and Hazim.

The Qasr Azraq series is particularly interesting. In the first place, there are specimens taken over a considerable period, viz. April–July. The April–May specimens are already considerably modified, being much yellower on the underside and more gleaming white on the upperside than spring brood *daplidice* from other parts of Transjordan. The July specimens are an extraordinarily exaggerated *albidice*. In some of them, the yellowish-brown (not green) markings on the underside are represented only by small spots on the margin at the extremity of the veins. I call this form (Pl. XV, fig. 13 ♂; Pl. XVI, fig. 40 ♂) *Pontia daplidice albidice* form **aridissima** nov. (type labelled "12 miles N.W. of Qasr Azraq, i.vii.1927, *L. K. Lockhart*," A. F. Hemming coll. No. 21290).

42. **Zegris eupheme uarda,** Hemming.

(Pl. XV, fig. 14 ♂, 15 ♀; Pl. XVI, fig. 41 ♂, 42 ♀.)

Zegris eupheme uarda, Hemming, 1929, Proc. Ent. Soc. Lond., **4** : 26, fig. 2, "Transjordan, Shunit Nimrin."

and

42A. **Zegris eupheme tigris,** Riley.

Zegris eupheme tigris, Riley, 1921, Ann. Mag. Nat. Hist., (9) **8** : 591, "Mesopotamia, Fathah, R. bank R. Tigris."

This species occurs as subspecies *uarda* in southern and central Transjordan and as *tigris* in northern Transjordan. The following are the localities in which it has so far been taken :—

ssp. *uarda,* Hem. :—Shunit Nimrin and the foot-hills to the E. of it (400 ft., or more, below sea-level), Wadi Musa, below El Gee (*Bewsher*) and (*Lockhart*) and Petra (*Philby*).
ssp. *tigris,* Riley :—Sukhni and desert 25 miles E. of Zerqa (*Lockhart*).

Subspecies *uarda* is nearest to ssp. *dyala,* Peile, discovered in Iraq, from which it is, however, readily separated by the outline of the mottled markings on the underside of the hindwings. In *dyala,* almost invariably, the outer margin of the mottled area describes a practically straight line, the remaining area of the wing (about one-third of the whole) being pure white, while in *uarda* there is in the latter area an extension of the mottling, an arm of which reaches the distal margin of the wing. Subspecies *tigris* is nearer to *dyala* than to *uarda,* but can be separated at once from either subspecies by the bright yellow apical patches to the forewings on the underside.

The flight period is rather short, the species emerging at the beginning of March (*e.g.* Shunit Nimrin, 3.iii) and being over by the middle of April.

43. **Euchloe belemia palaestinensis,** Rober.

Euchloe belemia, Esper, form *palaestinensis,* Rober, 1907, in Seitz, Grossschmett. Erde, **1** : 51, "Palestine."

This species was taken by Captain Lockhart on the road from the Allenby Bridge to Shunit Nimrin; E. of Tel Arbain; in the Wadi Zerqa; at Sukhni; Jerf-el-Derwish and Umm Jamal. Philby also took it at Petra (Graves 1925). All except one of Captain Lockhart's specimens belong to the smaller and darker form characteristic of the first half of the emergence and were taken between 3.iii and 3.iv. The solitary example of the form analogous to form *glauce,* Hb., of Spain and Portugal was taken at Umm Jamal on May 11th. It is a freshly emerged ♂ in which the *glauce* characters are more strongly developed on the underside than I have ever seen before. The apical markings to the forewings and the mottled markings on the hindwings are a dull rust colour and are very markedly reduced in size.

44. **Euchloe charlonia,** Donzel.

Anthocaris charlonia, Donzel, 1842, Ann. Soc. ent. France, **11** (2): 197, pl. 8, fig. 1 ♂, "Emsilah, en Barbarie."

The subspecies of *charlonia,* Donz., found in Transjordan and Palestine is, as Graves (1925) observes, much nearer to nominotypical *charlonia* from N. Africa than to *penia*, Freyer (1851), from the Lebanon. It differs, however, from either, and I name it :—

Euchloe charlonia elisabethae, ssp. n.

(Pl. XV, fig. 8 ♂, 9 ♀; Pl. XVI, fig. 35 ♂, 36 ♀.)

Nearest to *c. charlonia* from which it differs as follows :—

♂♀ *Upperside.* Ground-colour pale greenish-yellow instead of very pale orange-yellow. *Forewings.* Black apical markings do not extend beyond Interspace 3 (these normally extend as far as Interspace 2 in *c. charlonia*); costal margin and distal termen lack pink scaling (conspicuously present in *c. charlonia*). *Hindwings.* As in *c. charlonia. Underside. Forewings.* Apical patch dark greyish-green (without yellowish tinge seen in *c. charlonia*; no orange suffusion in the discal cell or along the costal margin (well marked in *c. charlonia*); pink scaling on costal margin and distal termen much less pronounced than in *c. charlonia. Hindwings.* Ground-colour dark greyish-green (without yellowish tinge seen in *c. charlonia*), with the result that the whitish discal spots stand out much more clearly against the ground-colour.

Average length of forewing : ♂ 17 mm., ♀ 18 mm. (♂ 16 mm., ♀ 17 mm. in *c. charlonia*).

Habitat. TRANSJORDAN : Shunit Nimrin, Tel-el-Makkasem, Sukhni, Kalaat-el-Hesa, Mafrak, Qoseir Halibat, Petra, Qasr Azraq, Jabir, Semme, Zerqa, and Gada (*Lockhart*); PALESTINE : Jericho (*Lockhart*, *Bewsher*, and *Graves*).

♂ *Holotype and* ♀ *allotype.* " Transjordan, foothills E. of Shunit Nimrin, –400 ft., 3.iii.1927, *L. K. Lockhart* " (A. F. Hemming coll. No. ♂ 19443, ♀ 19447).

Paratypes in Hemming coll. (♂ 12) and Bewsher colls.; also in British Museum, ♂ 1, " Transjordan, Nuwaiquis, 19.iii.1922, *H. St. J. Philby* " (B.M. Type No. Rh. 387) and ♂ 3 " Palestine, Jericho 17–21.iii.1921, *P. P. Graves* " (B.M. Types No. Rh. 388–390).

It will be seen from the above data that, though, in Palestine, it is confined to a small area in the Lower Jordan Valley, this species is widely distributed in Transjordan. The suggestion put forward by Graves (1925) that in this region in addition to the early spring brood this species has a winter brood (corresponding to f. *levaillantii*, Luc. (1847)) is confirmed by the material received from Captain Lockhart and Colonel Bewsher. When the Palestine records are included the available evidence in regard to this winter brood is as follows :—

TRANSJORDAN : Mafrak (17–26.xi), Jabir (23.xi), Semme (30.xi) (*Lockhart*), Zerqa (21.i) (*Bewsher*).

PALESTINE : Jericho (13.i), Old Jericho Road near Jericho and Wadi Kelt (27.i) (*Bewsher*).

These winter brood specimens are smaller than spring examples of *elisabethae*, the forewing in the males averaging only 14 mm. The ground-colour of the hindwings on the underside and the apical patches on the same surface are dark greyish-green, being considerably darker than in spring brood *elisabethae*.

The spring brood appears at the beginning of March (*e.g.* Jericho 1.iii and Shunit Nimrin 3.iii, *Lockhart*), or in exceptional years in the middle of February, *e.g.* at Jericho in 1922 (*Graves*), and extends throughout March to April or even in exceptional cases to May (*e.g.* Mafrak, 12.v, *Lockhart*).

45. **Euchloe crameri melisande,** Fruhst.*

Euchloe belia melisande, Fruhst., June 1908, Ent. Z. Frankfurt, **22** : 51, " Palastina."
Euchloe belia race *melisanda*, (Fruhst. *in litt.*), Verity, Nov. 1908, Rhop. Pal. : 177, pl. 36, fig. 42 ♂ (*melisande* on plate), " Jerusalem."
Euchloe belia race *melisanda* form *triangula*, Verity, Nov. 1908, *ibid.* : 176, pl. 36, fig. 34 ♂, pl. 50, fig. 10 ♂, " Jerusalem."

and

45A. **Euchloe crameri aegyptiaca,** Verity.

Euchloe belia race *aegyptiaca*, Verity, 1911, Rhop. Pal. : 337, pl. 67, fig. 28, 29 ♂, " Wadi Hof, Heluan, Egypte."

Described from specimens taken in the Wadi Hof at Heluan, the subspecies *aegyptiaca*, Verity, may be readily recognised by its small size and by the tendency of the green mottling on the underside of the hindwings to be arranged transversely in bands. So far, in Transjordan, it has only been found in the southern region where it was taken at Petra by Philby (11–31.iii.1922–23) and in the Wadi Musa by Captain Lockhart (30.iii.1927).

Elsewhere in Transjordan the subspecies found is *melisande*, Fruhst. There are two very distinct forms of this subspecies, viz. form *triangula*, Verity, which represents the first part of the annual emergence and the much larger and paler *melisande*, which is the form of the second part of the emergence. This subspecies was taken by Captain Lockhart between the Allenby Bridge and Shunit Nimrin, on the foothills east of Shunit Nimrin, in the Wadi Zerqa, and at Sukhni. It was also found at Es Salt by Mrs. Bewsher.

46. **Colotis fausta,** Olivier.

Papilio fausta, Olivier, [1804], Voy. Othoman, **4** : 29, pl. 33, fig. 4 A, B ♀, " Beirut."

This species was taken by Captain Lockhart at Jerash, Zerqa, Mafrak, and Sukhni. Graves (1925) records its capture by Philby at Petra, Amman, Wadi Sir, and Fuhais. Though fairly widespread, it does not appear to be plentiful in Transjordan. All Captain Lockhart's specimens were taken between September and November, except a freshly emerged pair taken at Jerash on July 29th. Philby, however, took a specimen at Petra as early as March 19th.

47. **Colotis phisadia palaestinensis,** Staudinger.

Idmais phisadia var. *palaestinensis*, Staudinger, 1898, Deuts. ent. Z. Iris, **10** : 271, " Ain-Dschiddi und Ghor-el-Safie."

This species was discovered by Bacher in December 1896 in Palestine on the west coast of the Dead Sea at Ain Jidi. In the second half of February 1897, he took one specimen in the Ghor-es-Safiye (in what is now Transjordan) at the S.E. end of the Dead Sea. It was found again in the latter locality by Philby who took ♂ 6, ♀ 2 in that locality on December 3rd, 1923.

* The name *ausonia*, Hb., has usually been applied to this species since the date when it was realised that *belia*, Linn., Cram. *nec* Linn., was not available, being only a misidentification of *belia*, Linn., which is the valid name given by Linnaeus to the ♀ of the species which he subsequently called *eupheno*. Unfortunately *ausonia*, Hb., as has been pointed out by Lord Rothschild (1914), is identical with the insect subsequently named *simplonia* by Freyer (1829) and Boisduval (1832). I am satisfied that *simplonia*, Boisd. (*i.e.* true *ausonia*, Hb.), is a distant species from that now usually called *ausonia*, Hb., and formerly (*e.g.* by Stgr., 1901, Cat. Lep., ed. 3 : 12) *belia*, Cram. The latter, therefore, requires a specific name. The oldest available is *crameri* proposed by Butler in 1869 as a nom. nov. pro *Papilio belia*, Linn., Cramer *nec* Linn., from Smyrna.

48. **Colotis chrysonome,** Klug.

Pontia chrysonome, Klug, 1829, in Ehrenberg, Symb. Phys. Ins., **1**, Signature G, pl. 7, fig. 9, 10 ♂, 11 ♀, " Ambukohl."

This species has only once been taken in Transjordan, viz. by Philby who caught ♂ 4, ♀ 1 in the Ghor-es-Safiye on December 3rd, 1923. It is probable, however, that it occurs elsewhere. Philby has taken it also in Arabia at Jidda (♂ 1 in British Museum 17.i.1926 and ♂ 2, 5.ii.1926).

49. **Zerene croceus,** Fourcroy.

Papilio croceus, Fourcroy, 1785, Ent. Paris : 250, No. 48, var. A ♂, var. B ♀, " Paris."

This species was taken at Amman; Shunit Nimrin; Sukhni; in the desert 25 miles E. of Zerqa; at Qasr Azraq; in the Wadi Rajil; in a wadi 12 miles N.W. of Qasr Azraq; 5 miles S. of Jerash; at Zerqa; and at Petra.

The ♀ form *helice*, Hb., seems to be scarce. Only two examples were taken, one at Sukhni (27.iii.1927) and the other at Zerqa (11.v.1928).

The species is on the wing for the greater part of the year, specimens being taken in every month from March to November.

PAPILIONIDAE.

50. **Papilio machaon sphyrus,** Hubner.

Papilio sphyrus, Hubner, 1823, Samml. europ. Schmett., **1**, [no text], pl. 155, figs. 775–6 ♀.

This species appears to be very local in Transjordan. I only received one specimen, a male, taken by Mrs. Bewsher (30.iii.1928) at Es Salt, between which place and Amman it was, however, fairly frequent on that day. Philby took this species at Petra, 25–28.iii (Graves 1925).

51. **Archon apollinus,** Herbst, ssp.

Papilio apollinus, Herbst, 1798, in Jablonsky, Nat. Ins. (Schmett.), **9** : 156, No. 49, pl. 250, fig. 5, 6 ♀ [" ♂ "], 7, 8 ♂ [" ♀ "], "Insel Ourlac."

This species was not known from Transjordan until Colonel Bewsher and Captain Lockhart found it flying on the tops of the hills immediately south of Amman, on 12th and 13th March 1928. Official duties made collecting impracticable on either day, and it is impossible, therefore, to determine to what subspecies Transjordan *apollinus* is referable. It is probable, however, that they are the same as those found in Palestine, in which case, they should be referred to ssp. *bellargus*, Stgr. (1891).

52. **Zerynthia cerisy speciosa,** Stichel.

Zerynthia cerisyi speciosa, Stichel, 1907, Ent. Z. Frankfurt, **21** : 83, " Syrien, Palastina."

This species appears to be very local in Transjordan. Captain Lockhart took one male (freshly emerged) at Ain Musa (30.iii.1927) and Mrs. Bewsher took 5 males (also freshly emerged) at Es Salt (30.iii.1928). Graves (1925) records its capture by Philby in the seasons 1922–23 at Jubaiha (23.iv), Es Salt (18.iv) and Amman (28.iii and 4.iv).

In view of the acceptance of such specific names as *Scolitantides lanty*, Obth. (1886), and *Melitaea yuenty*, Obth. (1886), there seems to be no need, or justification, for the pseudo-latinisation of Godart's *cerisy* into *cerisyi*.

HESPERIDAE.

53. **Scelotrix melotis,** Duponchel.

Hesperia melotis, Duponchel, 1834, in Godart, H.N. Lépid. France, Suppl., **1** (Diurnes) : 257, pl. 42, fig. 1, 2 ♂, " Ile de Milo."

This species which has not previously been taken in Transjordan was found by Captain Lockhart at El Hammie, a post on the Transjordan frontier, E. of the Jordan. These specimens are very different from *melotis* of the Lebanon and I name them :—

Scelotrix melotis jordana, ssp. n.

(Pl. XV, fig. 24 ♂, 25 ♂; Pl. XVI, fig. 51 ♂, 52 ♂.)

Differs from *m. melotis* as follows :—

♂♀ *Upperside.** *Forewings.* White spots squarer and much larger, the first spot of the discoidal series, the whole of the median series, the subcostal spots and the discoidal lunule being especially conspicuous. *Hindwings.* Spots in median row larger and squarer, those in the marginal row large and much more clearly defined. *Underside. Forewings.* Ground-colour whiter and white spots larger as on upperside. *Hindwings.* Much more unicolorous and much whiter, being devoid of the cream or buff tinge seen in *m. melotis.*

Average length of forewing : ♂ 14 mm., ♀ 15 mm. (♂ 13 mm., ♀ 14 mm. in *m. melotis*).

Habitat. TRANSJORDAN : El Hammie on the Palestine–Transjordan frontier (*Lockhart*) ; PALESTINE : Wadi Lemoon near Safed (*Lockhart*) ; Beisan (*Lockhart* and *Buxton*) ; Akka, Bitir, and Nazareth (*Buxton*).

♂ Holotype. " Transjordan El Hammie, 11.iii.1927, *L. K. Lockhart* " (A. F. Hemming coll. No. 10517).

♀ Allotype. " Palestine, 3 m. S. of Beisan (–750 ft. to –850 ft.) 19.vi.1923, *L. K. Lockhart* " (A. F. Hemming coll. No. 13423).

Paratypes. ♂ 1, El Hammie (same data as ♂ holotype) (A. F. Hemming coll. No. 10518) ; ♂ 1, " Wadi Lemoon 10.ix.1928, *L. K. Lockhart* " (A. F. Hemming coll. No. 27151) ; and others in Buxton coll.

According to the data available, the spring emergence takes place early in March, the second in May (earliest date 23.v.1922) and June (latest date 30.vi.1921). The only specimens hitherto recorded of the third brood were some ♂♂ taken by Buxton at Beisan at the end of July (23–28.vii.1922). The Lockhart material shows that this brood is also on the wing in September.

54. **Pyrgus doris amenophis,** Reverdin.

(Pl. XV, fig. 21 ♂, 22 ♀; Pl. XVI, fig. 48 ♂, 49 ♀.)

Hesperia amenophis, Reverdin, 1914, Bull. Soc. lép. Genève, **3** : 55, pl. 3, fig. 5 ♂, 11 ♀, pl. 4, fig. 1 (genitalia), " Egypte, Heliopolis."

Riley, who has recently re-arranged the named forms of this group represented in the British Museum collection, has shown that *amenophis*, Rev., should be placed as a subspecies of *doris*, Walker (1870, *Entomologist*, **5** : 56), described from " Tajora, Straits of Bab-el-Mendeb, Red Sea coast of Africa."

This subspecies which has not previously been taken in Transjordan differs from other subspecies of *doris* by the larger size of the white spots on the upperside and by the whiter ground-colour of, and reduction of markings on, the underside of the hindwings. Judging from the material now available, *amenophis* appears to be widely distributed, its known localities being as follows :—

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* In this and the following descriptions of new subspecies of this group, the nomenclature proposed for the markings by Warren (1926) has been adopted.

Egypt : Heliopolis, desert, 8.xi.1913 (♂ holotype) and 1.viii.1913 (♀ allotype) (*Andrès*) and ♀ 1, March 1915 (*Graves*); Wadi Rished near Helouan ♀ 1, end Oct., 1904 (*Graves*); Mokattam Hills, ♂ 1, 24.iv.1918 and ♂ 2, ♀ 1, 27.iv.1918 (*Graves*); Kassassin, ♀ 1, 23.x.1915 (*Graves*).

Sudan : ♂ 1, Jebel Angageh, 3.xi.1902 (*H. N. Dunn*), and ♀ 1, Angageh Wells, W. Kordofan, 13.xi.1902 (*H. N. Dunn*).

Transjordan : Qasr Azraq (1½ miles W. of the settlement), ♀ 1, 27.iv.1927 and Hazim, 35 m. S.E. of Qasr Azraq, ♂ 1, 2.vii.1927 (*Lockhart*).

Iraq : R. Dyala, Mirjana, ♂ 1 (worn), 28.vi.1919 (*H. D. Peile*).

55. **Pyrgus orbifer hilaris,** Staudinger.

Hesperia orbifer var. et ab. *hilaris*, Stgr., 1901, Cat. Lep., ed. 3: 96, No. 699 (a), "Mardin (var.); Syria, etc. (ab.)."

This species, which has not previously been taken in Transjordan, appears to be scarce. Colonel Bewsher took one female of the (large) spring emergence at Amman on May 19th, 1927, and Captain Lockhart a male on July 29th, 1927, in the Wadi Zerqa at the point where the Jerash road crosses the river. The latter specimen belongs to the (small) second brood and does not differ from examples of that brood from Palestine (*e.g.* Imam Ali 26.vii and Mt. Carmel 26.vii) which Graves has named form *secunda*, Graves (1925).

56. **Syrichtus hieromax,** sp. n.

(Pl. XV, fig. 23 ♂; Pl. XVI, fig. 50 ♂, and text-fig.)

Superficially nearer to *S. proto*, Esp. [1805–1808], and especially its subspecies *aragonensis*, Sagarra (1924),* than to any other species of the genus, from which, however, it differs as follows :—

♂ *Upperside.* Ground-colour blackish but with tinge of brown (absent in *proto*); the spots (which are white in all subspecies of *proto*) cream colour; fringes much less heavily chequered. *Forewings.* Of median row of spots, Nos. 1 and 2 are longer and No. 3 and (especially) 4 larger and squarer; No. 6 (absent in all subspecies of *proto*) present but very small; Nos. 7, 8, and 9 larger, their outer edge forming a straight line (in the various subspecies of *proto* No. 7 is usually out of alignment, being advanced towards the termen). Outer row of spots absent (complete but not clearly defined in *aragonensis* and other subspecies of *proto*). The discoidal lunule larger and squarer. The discal spot (present in all subspecies of *proto*) absent. *Hindwings.* The basal spot (No. 2 of the series) which alone is present is larger and squarer. Of the spots in the median band, Nos. 3 to 7 present (No. 7 usually absent in *proto*); No. 4 squarer and more pronounced. Marginal row clearly defined, the spots being much larger than in any subspecies of *proto*. *Underside.* Spots (white in *proto*) cream colour. *Forewings.* Ground-colour deep black, the whitish or yellowish suffusion seen in *proto* along the termen, absent and the corresponding suffusion (here reddish-brown) along the costal margin greatly reduced in extent. The veins outlined with yellowish-brown scaling. Of the median row, spots Nos. 1 to 4 large and sharply defined; No. 6 (absent in *proto*) present but small; Nos. 7, 8 and 9 very much larger than in any subspecies of *proto*, forming together a conspicuous cream-coloured patch. The discal spot, fairly well marked in all subspecies of *proto*, very narrow and indistinct. Spots in outer row vestigial (fairly large, though not very clearly defined in *proto*). *Hindwings.* Ground-colour darker than in any subspecies of *proto*, being dark greenish-brown instead of pale greenish-brown or pinkish-brown. Veins conspicuously outlined with pale yellowish-brown scaling. The cream-coloured spots much more clearly defined owing to the darker ground-colour. Basal spots as in *proto*. Median band complete, the spots being larger than in *proto* and the outer edge of spot No. 4 less concave. The spots in the marginal row (well defined in *proto*) small and indistinct, being also flatter and less V-shaped.

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* The comparison in the above description is drawn from a specimen of *S. proto aragonensis* taken at Albarracin, the type locality of that subspecies.

Average length of forewing : 14 mm. (15 mm. in *proto aragonensis* and 16 mm. in *proto proto*).

♂ *Genitalia* (fig. 3). The genitalia are, on the whole, nearest to those of *S. proto*, though, as will be seen from the following description, they resemble in certain important respects those of *S. mohammed*, Oberthur (1887). Uncus long and slender, but less so than in *proto*. (Relative length of uncus to that of clasp being 4 : 12 as compared with 6 : 12 in *proto*.) The so-called " lateral apophyses " (it is doubtful whether in this species or in *proto* these structures are strictly analogous to those seen in, say, *Scelotrix alveus*, Hb.) differ markedly from those of *proto* and are considerably nearer to those of *mohammed*. In *hieromax* these processes are much larger, their length in relation to that of the clasp being in the proportion 8 : 12, as compared with 5 : 12 in *proto*. Further, in *hieromax* they are roughly triangular in shape ; the dorsal side bearing a few sharp spines near the apex of the triangle ; the ventral side, which is much more heavily chitinised, bears a series of similar spines from the apex of the triangle for a distance of about one-half of the length of the process. In *proto*, these processes are much broader than in *hieromax* in relation to their length and at their outward extremity (*i.e.* that portion which corresponds to what in the case of *hieromax* has been called the apex of the triangle) are thicker, less pointed, and more upturned. The spines on these processes, which are so striking a feature of *hieromax* are, in *proto*, insignificant and poorly developed.

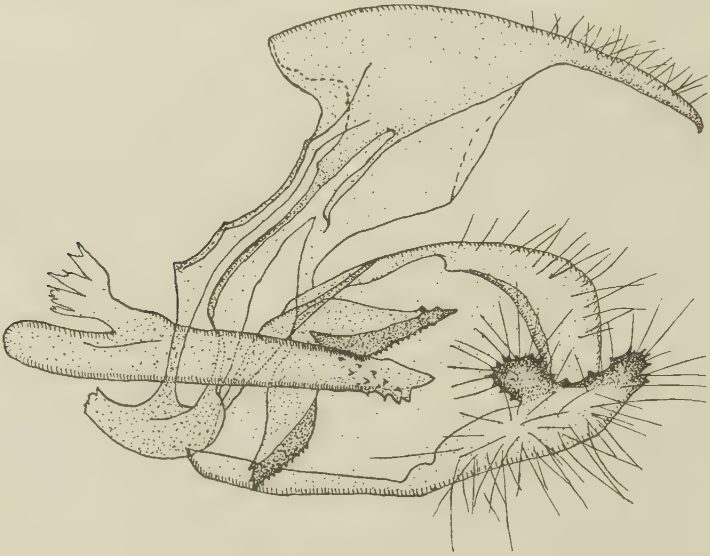

FIG. 3.—*Syrichtus hieromax*, sp. n. Genitalia of ♂ paratype.

The clasp is more or less oval in shape, as in *proto*. In both species the basal portion of the harpe is a very narrow structure, but in *hieromax* its distal end where it curves down towards the cuiller is relatively much broader than in *proto* and in this respect resembles that of *mohammed.* The cuiller, which in *proto* is of the same length as the ventral plate, is in *hieromax* relatively much longer, standing to the ventral plate in the proportion 36 : 29. As in *proto,* the cuiller is divided at its termination into two heavily chitinised prongs. In *hieromax,* these processes which bear a large number of stout spines are of approximately equal size and similar shape. The incurved strip of chitin by which they are separated is heavier (*i.e.* thicker) than is the rest of the cuiller and bears two conspicuous spines. In *proto,* however, the two processes are dissimilar in shape, the inner one resembling the corresponding process in *hieromax,* but the outer one being smaller and more pointed. There are fewer spines on both of these processes than in *hieromax.* The intervening strip is not more heavily chitinised than the rest of the cuiller and bears no spines. The ventral plate, in *hieromax,* is (as stated above) considerably shorter than the cuiller, instead of being the same length as in *proto.* It is a featureless strip of almost equal size throughout its length. In *proto,* however, this plate is convex, being curved upwards towards the centre of the clasp.

The oedoeagus is more massive in *hieromax* than in *proto.* It bears a far more conspicuous series of spines towards its apex than does that of *proto.*

Habitat. TRANSJORDAN : Ajlun.

♂ *Holotype.* "Transjordan, 1½ miles W. of Ajlun, 6.x.1927, *L. K. Lockhart*" in Hemming coll. (A. F. Hemming coll. No. 21936).

Paratypes. ♂ 4, same locality and date as holotype in Hemming coll. (A. F. Hemming coll. Nos. 21935, 21937–38) and in British Museum (B.M. Type No. Rh. 379).

The structural differences disclosed in the preceding description fully justify the separation of *hieromax* as a species distinct from *proto.* Indeed, as has been shown, *hieromax* is probably more closely allied to the Algerian *mohammed* than to that species.

So far, Captain Lockhart's are the only known specimens of *hieromax.* As regards *proto,* from the Middle-East the nearest localities from which I have seen specimens (in the Graves collection) are Wadi Biar on the plateau west of Jerusalem (♂ 1, 16.x.1921, *P. A. Buxton*) and the Cedars of Lebanon, 6000–6600 ft. (♂ 3, end viii.1910, *P. P. Graves*). These examples belong to the subspecies named *lycaonius* by Wagner (1929) from specimens taken at Akschehir in Inner Anatolia, a paratype of which is in the Graves collection. That this should be so is significant, as *lycaonius* differs considerably from *aragonensis,* the subspecies of *proto* which superficially most closely resembles *hieromax.*

57. **Carcharodus fritillarius australis,** Zeller.

Papilio Plebeius fritillarius, Poda, 1761, Ins. Mus. Graec : 79, No. 53, "Gratz."

Papilio fritillum, Schiffermuller, 1775, Schmett. Wien : 159, No. A 3, nom. nov. pro *P. fritillarius,* Poda.

Papilio Pl. U. alceae, Esper, 1780, Die Schmett., **1,** (Bd. 2) Forts. Tagschmett. : 4, pl. 51, fig. 3 ♀, "Erlang."

Hesperia malvarum, Hffsg., var. *australis,* Zeller, 1847, Isis, (Oken), **1847** : 285, "Syracuse, Catania, Messina."

This species, though never common, is widely distributed in Transjordan where it was taken by Captain Lockhart in the Wadi-el-Arab near Esh Shuni, in the Wadi Musa, at Sukhni, Umm Jamal, Habeibe, Jerash, Es Salt, Kafringi, Ajlun, Petra, and Zerqa. Philby took it at Ain Sara on the E. shore of the Dead Sea (Graves 1925).

The first brood emerges in March (*e.g.* Wadi-el-Arab 12.iii) and continues through April till mid-May (Umm Jamal 11.v, ♂ 1 in fair condition). The second brood appears in July (Zerqa 13.vii) and, no doubt, continues into August, though I have no Transjordan specimens taken in that month. The third brood is on the wing in September and October (*e.g.* Sukhni 9.ix, Kafringi 6.x).

It is curious that Poda's name *fritillarius* should have so long been neglected, as his description leaves no room for doubt regarding its identity. He says that it is a *Papilio Plebeius* with brown wings without tails, with squarish white spots, some solitary, others contiguous. He adds that these white spots are "*subdiaphanae.*" This excludes all species of *Scelotrix* and points at once to *alceae*, Esp. The only author who has correctly identified *fritillarius* is Schiffermuller, who, after re-naming it *fritillum*,* quotes as a synonym the "Plein-Chant" of Geoffroi, which is *alceae* and gives a reference to Rosel, Tom. 1, Classe 1 Pap., pl. 10, fig. 7, which is also *alceae.*

58. **Carcharodus ramses,** Reverdin.

(Pl. XV, fig. 20 ♀; Pl. XVI, fig. 47 ♀.)

Carcharodus ramses, Reverdin, 1914, Bull. Soc. lép. Genève, **3** : 38, pl. 3, fig. 9 ♂, "Egypte, Maryot, près d'Alexandrie."

The specimens taken in Palestine and Transjordan attributed by Graves (1925) to *baeticus*, Ramb. (1842), *i.e.* to *marrubii*, Ramb. (1842), prove on examination to belong to *C. ramses*, Rev. From the small amount of material now available, the known distribution of this species is as follows :—

EGYPT : Maryot Steppe near Alexandria (*Graves*); Western desert, about 6 m. S.W. of Mersa Matruh, Wadi Ramlah (*R. S. Wilson*).

TRANSJORDAN : Zerqa (*Lockhart*) and Jerash (*Philby*).

PALESTINE : North of Beisan (between –300 ft. and –500 ft.) (*Lockhart*); Ras-el-Ain (*U. Bewsher*); 10 miles E. of Jerusalem, Tel-el-Milh near Beersheba (*Buxton*); Ain Karim (*Graves* 1925).

SYRIA : Zebedani, 1900 (*Nicholl*).

The female of this scarce species does not appear to have been described, and I therefore give the following description :—

Upperside. Ground-colour of the forewings and hindwings less contrasted than in the ♂. The tone of that of the forewings reddish-brown, that of the hindwings darker but with a reddish shade absent in the ♂. *Forewings.* Submedian band of palish yellow scaling, which is relatively well marked in the ♂ is in the ♀ very strongly developed. *Hindwings.* Spots in medial and sub-discal rows larger, the former forming a more or less continuous band.

Underside. Forewing. Ground-colour much paler, the areas which are blackish in the ♂ are in the ♀ pale yellowish-grey; white spots and other markings almost obliterated. *Hindwing.* Ground-colour pale reddish-orange; the white markings yellowish and very indistinct (fairly well marked in the ♂).

Length of forewing : 13 mm. (14 mm. in the ♂).

♀ *Neallotype.* "Transjordan, Zerqa, 18.v.1928 (*L. K. Lockhart*)" (A. F. Hemming coll. No. 27111). Other females taken by Captain Lockhart are a second specimen from Zerqa (same data as neallotype) and two from Palestine (Beisan –300 ft. to –500 ft. 16.v.1923).

All Captain Lockhart's specimens were taken in May (Zerqa 4–18.v and Beisan 16.v). Mrs. Bewsher's Ras-el-Ain specimen was taken on May 21st,

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* The name *fritillum* can no longer be applied to the *Scelotrix* species to which it is usually given, since it is based on a misidentification. That species should now therefore be called *Scelotrix cirsii*, Ramb. (1842).

1927. The dates of capture of the other specimens are given by Graves (1925). They are all in May except that of the specimen taken 10 miles E. of Jerusalem, which was caught by Buxton on April 17th, 1922. There is thus no evidence of there being a second brood in Transjordan or Palestine. In Egypt the species appears at the beginning of April (type series taken 5.iv.1913).

59. **Carcharodus orientalis,** Reverdin.

Carcharodus orientalis, Reverdin, 1913, Bull. Soc. lép. Genève, **2** : 232, pl. 21, fig. 14 ♂, pl. 22, fig. 1 (wing), fig. 8 (genit.), " Péloponèse."

Transjordan and Palestinian specimens differ constantly from nominotypical *orientalis* from the Peloponnese and I describe them as follows :—

Carcharodus orientalis maccabaeus, ssp. n.

(Pl. XV, fig. 18 ♂, 19 ♀; Pl. XVI, fig. 45 ♂, 46 ♀.)

Differs from nominotypical *orientalis* as follows :—

♂♀ *Upperside.* Ground-colour paler and bluish-grey (dark brownish-grey in *o. orientalis*); veins (forewings and hindwings) clearly outlined with paler grey scales (in *o. orientalis* veins on forewing outlined faintly or not at all, on hindwings without any outlining). *Forewing.* Discoidal spot larger and squarer, but this and other spots are less distinct owing to paler ground-colour. *Hindwing.* Spots in medial and sub-discal rows larger and squarer, the former in some females forming a broad continuous white band.

Underside. Ground-colour of forewings similar to that of *o. orientalis,* that of hindwings similar to those specimens of *o. orientalis* which are pale grey (no specimens have the brownish tinge not infrequently found in *o. orientalis*); white spots (forewings and hindwings) larger and squarer as on upperside.

Length of forewing : ♂ 15 mm., ♀ 16 mm. (♂ 14 mm., ♀ 15 mm., in *o. orientalis*).

Habitat. TRANSJORDAN : Sukhni, N. of Zerqa, Zerqa, and Petra (*Lockhart*); Wadi Sir (*Philby*). PALESTINE : Nablus, Tulkeram, Mt. Carmel (*Lockhart*), Bethlehem (*Baynes*). SYRIA : Mt. Hermon, Ain Arba (*Nicholl*). ANTI-LEBANON : Baalbek (*Graves*).

♂ *Holotype.* " Transjordan Sukhni, N. of Zerqa, 3.iv.1927, *L. K. Lockhart* " (A. F. Hemming coll. No. 19516).

♀ *Allotype.* " Transjordan Sukhni, N. of Zerqa, 9.iv.1927, *L. K. Lockhart* " (A. F. Hemming coll. No. 19772).

Paratypes. ♂, " Sukhni 9.iv.1927, *L. K. Lockhart* " and ♀ 1, " Zerqa 15.iv.1928, *L. K. Lockhart* " in Hemming coll. (A. F. Hemming coll. No. 19771 and 27106) and ♂ 2 in British Museum, " Bethlehem, v.1923, *C. A. Baynes* " (B.M. Types No. Rh. 376, 377).

This species appears to be double-brooded both in Transjordan and Palestine. In the former country, Captain Lockhart took it in April (3–15.iv) and Philby took it in August (14.viii.1923). In Palestine, also, the first brood emerges in April (*e.g.* Tulkeram, 7.iv and Nablus 13.iv) and extends to June (*e.g.* Mt. Carmel, 29.vi.1928, one worn ♀). The only second-brood specimen that I have from Palestine was taken by Captain Lockhart on Mt. Carmel in 1927 on September 17th. This example and Philby's August specimens from Wadi Sir are smaller than those taken earlier in the year, but the difference between the two broods is certainly not sufficient to justify a name being given to the summer brood as a seasonal form distinct from the spring brood *maccabaeus.*

60. **Gegenes nostrodamus,** Fabricius.

Hesperia Urbicola nostrodamus, Fabr., 1793, Ent. Syst., **3**, (1) : 328, No. 246, "Barbaria."

This species, which is new for Transjordan, was taken by Captain Lockhart in 1927 at Zerqa, Jerash, and Sukhni. The earliest and latest dates (both Zerqa) are 29.vii and 25.ix. In all, nine specimens were taken (♂ 5, ♀ 4).

61. **Gegenes pumilio,** Hoffmansegg.

Papilio pumilio, Hoffmansegg, 1804, Mag. Insektenk. (Illiger), **3** : 202, nom. nov. pro *pygmaeus*, Hb., figs. 458–460, "Calabrien, *Hubner*."

Papilio pumilio, Hoffmansegg, Hubner, 1805, Samml. europ. Schmett., **1** : 72, No. 15, "Calabrien."

Papilio Plebeius Urbicola pigmaeus, Esper, 1793, Die Schmett. Supp., **1**, Abschn. Tagschm. : 34, pl. 99, fig. 3 ♀, "Sudlich. Italien."

Papilio pygmaeus, Fabricius, Hubner, *nec* Fabricius, 1803, Samml. europ. Schmett., **1**, pl. 91, fig. 458 ♂, 459, 460 ♀.

Philoodus lefebvrii, Rambur, 1842, F. Ent. Andal., **2** : 308 (*nota*), "Naples et Sicile."

Hesperia lefebvrii, Rambur, 1858, Cat. syst. Lép. Andal. : 90 (*nota*), "Midi de l'Italie, la Sicile, la Sardaigne."

This species appears to be scarcer in Transjordan than *nostrodamus*. Captain Lockhart only met with it in 1927, when he took it at Zerqa (♀ 1, 4.ix, and ♂ 1, 25.ix) and at Sukhni (♂ 1, 9.ix). Philby took one female in the Wadi Sir, 14.viii.1923 (Graves 1925).

This species is usually known by Rambur's name *lefebvrii* (1842) which, however, falls before *pumilio*, Hffsg. (1804). The latter was expressly proposed by Hoffmansegg as a substitute for *Papilio pygmaeus*, Hb. (1803), which is this species, but which, with *pigmaeus*, Esp. (1793), falls as a primary homonym of *Papilio pygmaeus*, Fab. (1775).

62. **Baoris mathias thrax,** Hb.

Gegenes thrax, Hübner, [*c*. 1819–1826], Exot. Schmett., **2** : Tab. *Gegenes*, fig. 1, 2 ♂, 3, 4 ♀.

Hesperia thrax, Fab., Lederer, 1855, Verh. zool.-bot. Ver. Wien, **5** : 194, pl. (Lederer) 1, fig. 9 ♂, 10 ♀, "Beirut; Tarsus (Karamanien)."

This species, which is new to Transjordan, was taken by Captain Lockhart in 1927 at Sukhni (9.ix, ♂ 1 freshly emerged), at Zerqa (25.ix. ♀ 3) and in the Wadi Yabis (7.x, ♂ 2).

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ROTHSCHILD, Lord. 1914, Novitates Zool. Tring, **21** : 302.
VERITY, R. 1913, J. Linn. Soc. Lond. (Zool.), **32** : 173–191.
WARREN, B. C. S. 1927, Trans. Ent. Soc. Lond., **74** : 44.

LIST OF NEW SPECIES, ETC., DESCRIBED IN THE FOREGOING PAPER.

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Pontia daplidice albidice, Oberthur, form *aridissima*, n.	284
Euchloe charlonia elisabethae, ssp. n.	287
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Carcharodus ramses, Reverdin ♀ neallotype described	294
Carcharodus orientalis maccabaeus, ssp. n.	295

List of Localities Mentioned.

Abu-Hajal, Tel	Hill, 2 miles S. of Jerash, 1,800 ft.
Ajlun	Town, 10 miles N.W. of Jerash.
Allenby Bridge	River bridge over R. Jordan, E. of Jericho,–1,250 ft.
Amman	Capital town of Transjordan, 2,850 ft.
Amruh, Qasr	Ruined castle, 15 miles W. of Qasr Azraq.
Anaizah	Railway station on Hedjaz Railway, 20 miles N. of Maan, 3,400 ft.
Aqaba	Town at head of Gulf of Aqaba, Red Sea.
Arab, Wadi-el	River valley in the Ghor, 8 miles S. of Samakh.
Arbain, Tel-el	Hill in the Ghor, 6 miles N.E. of Beisan,–750 ft.
Ayub, Bir	Village, W. of Amman.
Azraq	Desert oasis, 55 miles E. of Zerqa.
Debaa, Kalat-ed	Railway station on the Hedjaz Railway, 25 miles S. of Amman, 2,345 ft.
Deir-el-Liye	Village, 4 miles N.W. of Jerash.
Fuhais	Village, 4 miles E. of Es Salt.
Gada	Desert ruins, 4 miles N.E. of Zerqa.
Habeibe	Rainwater pools, 25 miles N.W. of Azraq.
Halibat, Qoseir	Ruined castle, 10 miles S.E. of Umm Jamal.
Hammie, El	Sulphur springs, Frontier Railway station, 5 miles E. of S. end of the Sea of Galilee.
Hazim	Desert wells, 35 miles S.E. of Qasr Azraq.
Hesa, Kalat-el	Railway station on Hedjaz Railway, 48 miles N. of Maan, 2,530 ft.
Hesban, Ain	Spring, 15 miles S.S.E. of Es Salt.
Jabir	Deserted ruins on northern frontier, on Hedjaz Railway, 10 miles S.E. of Deraa (Syria), 1,986 ft.
Jemeime	Village in Wadi Kafringi, 3 miles S.W. of Kafringi.
Jerash	Town in Central Transjordan.
Jerf-el-Derwish	Railway Station on Hedjaz Railway, 30 miles N. of Maan, 2,800 ft.
Jubaiha	Village, 10 miles N.W. of Amman, 3,500 ft.
Kafringi	Village, 5 miles S.W. of Ajlun, approximately 2,000 ft.
Kerak	Town in Moab, 3,110 ft.
Kurma, Jebel	Hills, 20 miles E. of Qasr Azraq.
Maan	Town, 120 miles S. of Amman, on Hedjaz Railway, 3,300 ft.
Mafrak	Railway station on Hedjaz Railway, 20 miles N. of Zerqa.
Makkasem, Tel-el	Hill in the Ghor on the Zerqa River, 15 miles N.W. of Es Salt.
Musa, Ain	Spring, 15 miles N.W. of Maan, 3,300 ft.
Nuwaiquis	Village near Amman.
Petra	Ruins, S.W. Transjordan, 3,000–4,000 ft.
Rajil, Wadi	Valley depression, 1 mile N.W. of Jebel Kurma.
Rusaifa	Village on Hedjaz Railway, 7 miles N. of Amman.
Safiye, Ghor-es	Region at S.E. end of Dead Sea, elev.–1,292 ft.
Salt, Es	Town on road between Allenby Bridge and Amman, 2,050 ft.
Sara, Ain	Spring, E. coast of Dead Sea,–1,292 ft.
Semme	Deserted ruins on northern frontier, 5 miles S.E. of Jabir.
Shaib, Wadi	River valley running S. from Es Salt.
Shuni, Esh	Village, 8 miles S. of Sea of Galilee.
Shunit Nimrin	Village, 7 miles E. of Allenby Bridge,–730 ft.

Sir, Wadi	Valley, 8 miles S.E. of Es Salt, 2,200 ft.
Suada, Jebel (Osha, Jebel)	Mountains immediately N. of Es Salt, 3,000–4,000 ft.
Sukhni	Village in Wadi Zerqa, 5 miles N. of Zerqa.
Umm-ed-Daraj, Jebel	Mountain, 5 miles S.E. of Ajlun, 4,000 ft.
Umm Jamal	Deserted ruins on northern frontier, 15 miles E. of Hedjaz Railway at Mafrak.
Weineid, Qasr	Ruined castle, 4 miles S. of Qasr Azraq.
Yabis, Wadi	River valley, 20 miles S. of Sea of Galilee (butterflies caught at a point 2 miles E. of R. Jordan).
Zerqa	Village on Hedjaz Railway, 12 miles N. of Amman (Headquarters of Transjordan Frontier Force).

Note.—The spelling of place-names is that shown on the map issued by the Geographical Section, General Staff, No. 2321 (Syria), sheets (1) Jaffa–Damascus, (2) Jerusalem. Scale $\frac{1}{250,000}$.

EXPLANATION OF PLATES XV AND XVI.

PL. XV. Fig.	PL. XVI. Fig.	
1.	28.	*Polyommatus loewii lockharti*, Hemming. ♂ holotype. Transjordan, 1½ miles west of Qasr Azraq, 24.iv.1927 (*L. K. Lockhart*).
2.	29.	*Polyommatus loewii lockharti*, Hemming. ♀ allotype. Transjordan, 1½ miles west of Qasr Azraq, 27.iv.1927 (*L. K. Lockhart*).
3.	30.	*Polyommatus loewii lockharti*, Hemming. ♀-form *margaritae*, Hemming. Type. Transjordan, 1½ miles west of Qasr Azraq, 24.iv.1927 (*L. K. Lockhart*).
4.	31.	*Polyommatus loewii antilibanotica*, Hemming. ♂ holotype. Antilebanon, Baalbek, 13.vi.1928 (*L. K. Lockhart*).
5.	32.	*Polyommatus loewii antilibanotica*, Hemming. ♀ allotype. Antilebanon, Baalbek, 13.vi.1928 (*L. K. Lockhart*).
6.	33.	*Plebeius pylaon philbyi*, Graves. ♂. Transjordan, 25 miles east of Zerqa, 15.iv.1927 (*L. K. Lockhart*).
7.	34.	*Plebeius pylaon philbyi*, Graves. ♀. Transjordan, 25 miles east of Zerqa, 15.iv.1927 (*L. K. Lockhart*).
8.	35.	*Euchloe charlonia elisabethae*, Hemming. ♂ holotype. Transjordan, foothills E. of Shunit Nimrin, 3.iii.1927 (*L. K. Lockhart*).
9.	36.	*Euchloe charlonia elisabethae*, Hemming. ♀ allotype. Transjordan, foothills E. of Shunit Nimrin, 3.iii.1927 (*L. K. Lockhart*).
10.	37.	*Melitaea didyma sargon*, Hemming. ♂ holotype. Baghdad (*W. K. Loftus*).
11.	38.	*Melitaea didyma sargon*, Hemming. ♀ allotype. Baghdad (*W. K. Loftus*).
12.	39.	*Melitaea didyma sargon*, Hemming. ♀ paratype. Transjordan, Wadi Rajil, N.W. of Jebel Kurma, 20.iv.1927 (*L. K. Lockhart*).
13.	40.	*Pontia daplidice albidice*, Oberth., form *aridissima*, Hemming. ♂ holotype. Transjordan, 12 miles N.W. of Qasr Azraq, 1.vii.1927 (*L. K. Lockhart*).

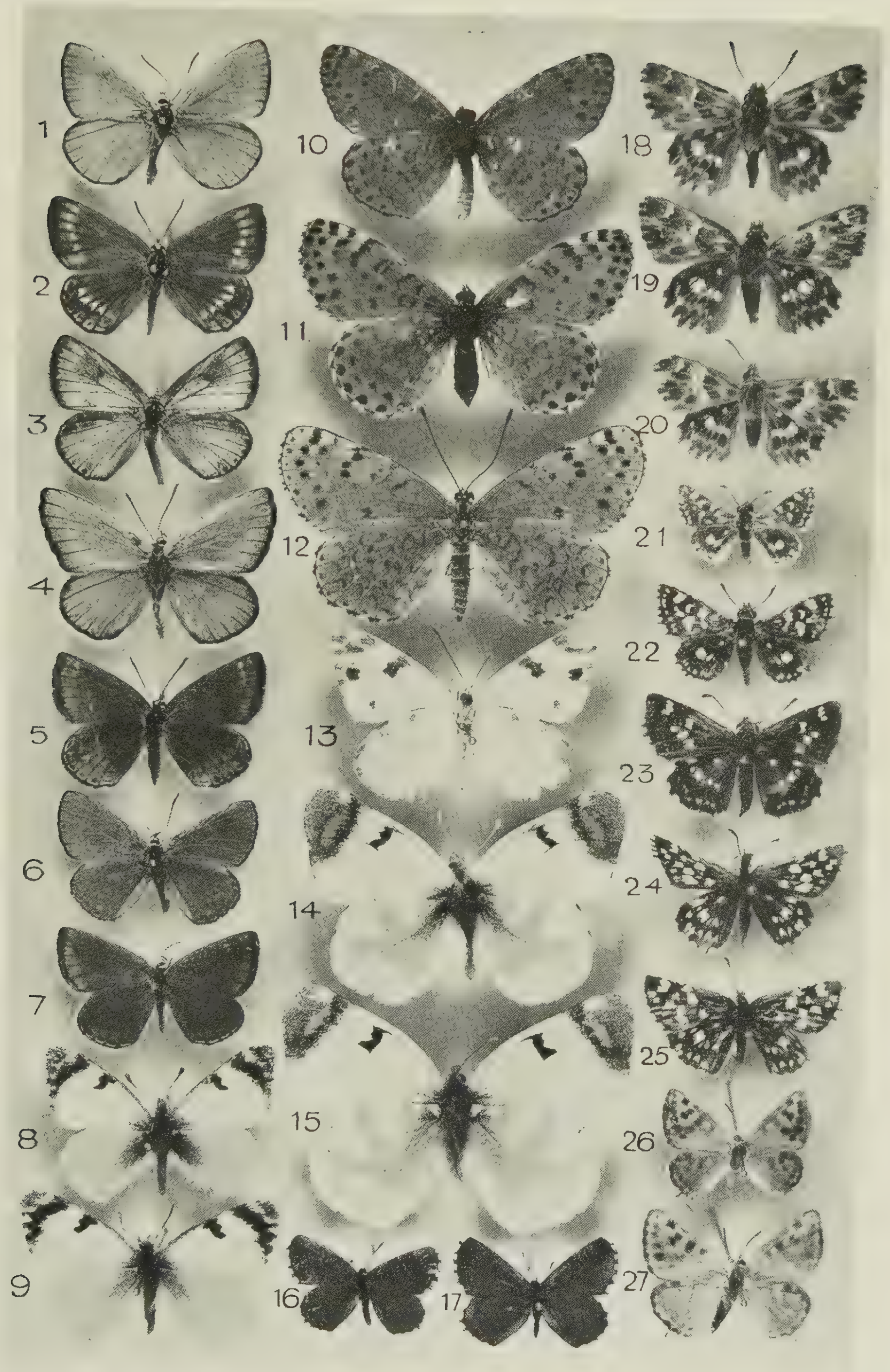
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Photo. W.H.T. Tams.

Butterflies from Transjordan, etc.

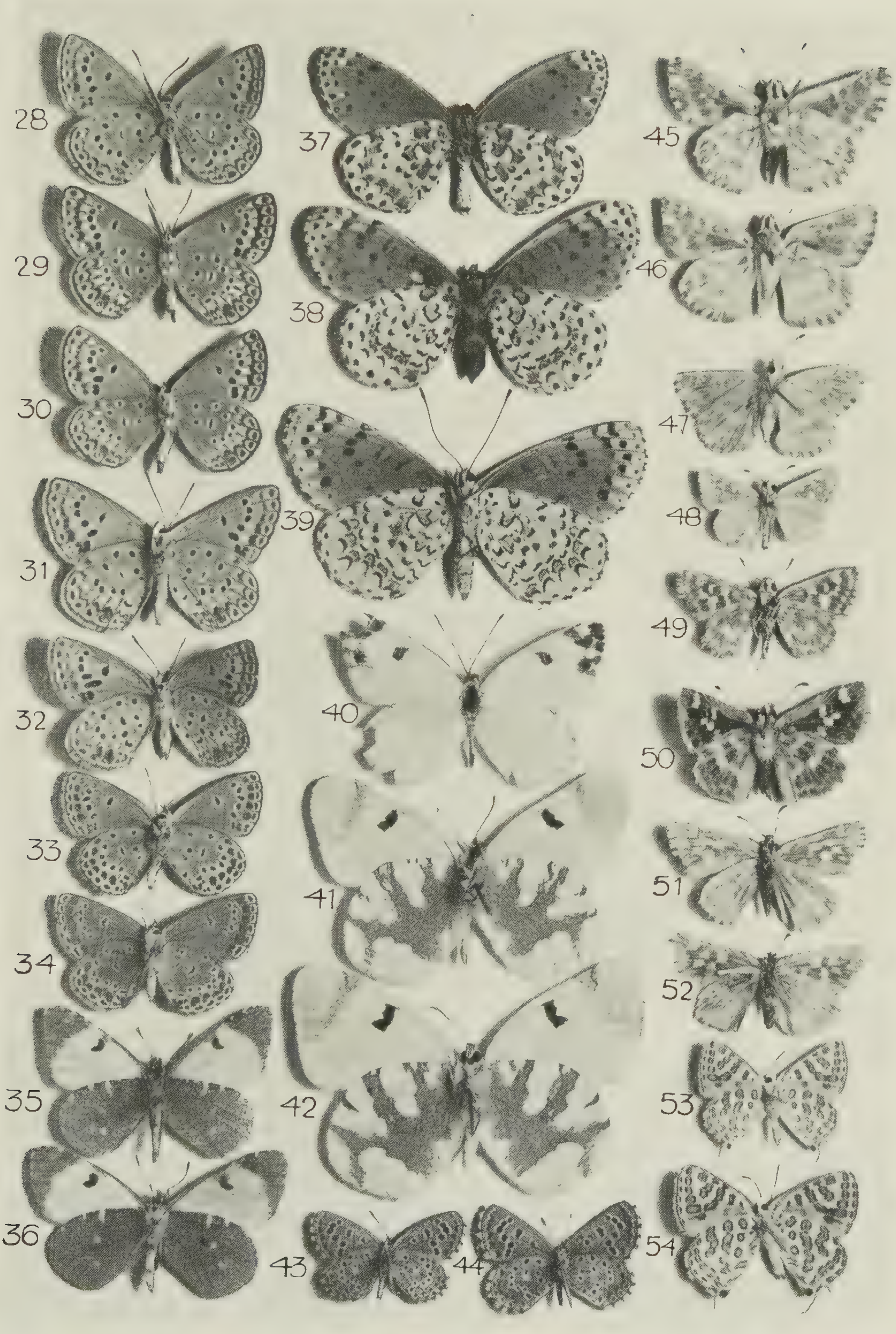
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Photo. W.H.T. Tams.

Butterflies from Transjordan, etc.

Pl. XV. Fig.	Pl. XVI. Fig.	
14.	41.	*Zegris eupheme uarda*, Hemming. ♂ holotype. Transjordan, Shunit Nimrin, 5.iii.1927 (*U. Bewsher*).
15.	42.	*Zegris eupheme uarda*, Hemming. ♀ allotype. Transjordan, Shunit Nimrin, 3.iii.1927 (*U. Bewsher*).
16.	43.	*Philotes abencerragus nabataeus*, Graves. ♂. Transjordan, one mile S.W. of Qasr Azraq, 28.iv.1927 (*L. K. Lockhart*).
17.	44.	*Philotes abencerragus nabataeus*, Graves. ♀. Transjordan, 25 miles east of Zerqa, 15.iv.1927 (*L. K. Lockhart*).
18.	45.	*Carcharodus orientalis maccabaeus*, Hemming. ♂ holotype. Transjordan, Sukhni, N. of Zerqa, 3.iv.1927 (*L. K. Lockhart*).
19.	46.	*Carcharodus orientalis maccabaeus*, Hemming. ♀ allotype. Transjordan, Sukhni, N. of Zerqa, 9.iv.1927 (*L. K. Lockhart*).
20.	47.	*Carcharodus ramses*, Reverdin. ♀ neallotype. Transjordan, Zerqa, 18.v.1928 (*L. K. Lockhart*).
21.	48.	*Pyrgus doris amenophis*, Reverdin. ♂. Transjordan, Hazim, 35 miles S.E. of Qasr Azraq, 2.vii.1927 (*L. K. Lockhart*).
22.	49.	*Pyrgus doris amenophis*, Reverdin. ♀. Transjordan, Qasr Azraq, 27.iv.1927 (*L. K. Lockhart*).
23.	50.	*Syrichtus hieromax*, Hemming. ♂ holotype. Transjordan, 1½ miles west of Ajlun, 6.x.1927 (*L. K. Lockhart*).
24.	51.	*Scelotrix melotis jordana*, Hemming. ♂ holotype. Transjordan, El Hammie, 11.iii.1927 (*L. K. Lockhart*).
25.	52.	*Scelotrix melotis jordana*, Hemming. ♂ paratype. Transjordan, El Hammie, 11.iii.1927 (*L. K. Lockhart*).
26.	53.	*Apharitis myrmecophila*, Dumont. ♂. Transjordan, Hazim, 35 miles S.E. of Qasr Azraq, 2.vii.1927 (*L. K. Lockhart*).
27.	54.	*Apharitis myrmecophila*, Dumont. ♀. Transjordan, 2 km. south of Qasr Azraq, 5.vi.1927 (*L. K. Lockhart*).

Note.—Plate XV represents the upperside, and Plate XVI the underside of the specimens figured, in every case except fig. 13 and fig. 40, where the under- and upper-surfaces are reversed. All the specimens figured are in the Hemming coll. except Nos. 10 and 11 (37, 38), which are in the British Museum.

A REVISION OF THE ETHIOPIAN SPECIES OF THE GENUS *APANTELES* (HYM. BRACON.)

J.N.R.

By D. S. Wilkinson.

(Imperial Institute of Entomology.)

[Read 1st June, 1932.]

Plate XVII.

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General Key :

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Introduction.

With the publication of this paper, my revisions for the genera *Apanteles*, *Microgaster*, and *Microplitis*, from the Indo-Australian and Ethiopian regions, are complete (*vide*, 1928, *Bull. Ent. Res.*, **19** : 79–146; 1930, **21** : 23–27; 1929, *Trans. Ent. Soc. Lond.*, **77** : 99–123). That large numbers of species still, however, await description I am only too well aware; but these revisions will, I am confident, at least form a basis for future work.

The present paper deals, I believe, with every species of *Apanteles* so far described from the Ethiopian region, but of these, unfortunately, nine are not known to me. No attempt has been made to include in this paper various writers' fairly numerous references to records of captures or various references to the identity of hosts; I have written only on material actually before me.

The nomenclature employed in this paper is the same as in my previous revisions. Explanation of the group-lettering will be found in the introduction to the General Key.

I desire here to express my sincere gratitude to the authorities of the following Museums for permitting to be sent to me various types and cotypes for examination :—The Zoological Museum, Berlin; the Transvaal Museum; and the South African Museum.

TRANS. ENT. SOC. LOND. 80. PART II. (DEC. 1932.)

GROUP M.

Apanteles insolens, Wilkn.

Apanteles insolens, Wilkinson, 1930, Bull. Ent. Res., **21** : 276.

This species was originally described from 6 ♀♀, 5 ♂♂, from SOUTH AFRICA, and the type and cotypes are in the British Museum.

Host unknown.

Cocoons unknown.

Apanteles pistrinariae, Wilkn.

Apanteles pistriñariae, Wilkinson, 1929, Bull. Ent. Res., **20** : 443.

This species was originally described from 26 ♀♀, 1 ♂, and 3 of indeterminable sex, from SOUTHERN NIGERIA, and the type with numerous cotypes is in the British Museum.

Host. Larvae of the Pierid butterfly *Mylothris chloris,* F.

Cocoons, pale buff, arranged like a pile of drain-pipes, regularly one above the other so that both ends are exposed (Pl. XVII, fig. 2).

Apanteles pistrinariae nyasaensis, Wilkn.

Apanteles pistrinariae nyasaensis, Wilkinson, 1929, Bull. Ent. Res., **20** : 445.

This subspecies was originally described from 26 ♀♀, 29 ♂♂, from NYASALAND, and the type with numerous cotypes is in the British Museum.

Host unknown.

Cocoons arranged as in *A. pistrinariae,* Wilkn., but rather paler.

GROUP A.

Apanteles laxatus, Wilkn.

Apanteles laxatus, Wilkinson, 1930, Bull. Ent. Res., **21** : 485.

This species was originally described from 8 ♀♀, 1 ♂, from UGANDA, and the type with some cotypes is in the British Museum.

Host unknown : the parasites are labelled " No. 6747."

Cocoons unknown.

Apanteles gratiosus, Wilkn.

Apanteles gratiosus, Wilkinson, 1930, Bull. Ent. Res., **21** : 150.

This species was originally described from 43 ♀♀, 36 ♂♂, from UGANDA, and the type with numerous cotypes is in the British Museum.

Host unknown.

Cocoons red-brown.

Apanteles pallidocinctus, Gahn.

Apanteles pallidocinctus, Gahan, 1918 (1919), Proc. U.S. Nat. Mus., **54** : 588; Wilkinson, 1928, Bull. Ent. Res., **19** : 81 (under *papilionis*); Wilkinson, 1929, Bull. Ent. Res., **20** : 107 (under *papilionis*); Wilkinson, 1930, Bull. Ent. Res., **21** : 150, 151.

This species was originally described from 6 ♀♀ from UGANDA, and the type is in the U.S. Nat. Mus. with one cotype in the British Museum.

In addition to the above-mentioned cotype, this species is also known to me from the following series, representatives of which are now also in the British Museum :—KENYA COLONY : Kabete, 1 ♀, 1 ♂, 27.xi.1918 (*T. J. Anderson*).

Uganda: Bugoma, 1 ♀, 1 ?, 16.vi.1910 (*C. C. Gowdey*); Kampala, 6 ♀♀, 15.vii.1916 (*C. C. Gowdey*), 5 ♀♀, 12.vi.1927 (*H. Hargreaves*), 7 ♀♀, 1 ♂, 2.viii.1927 (*H. Hargreaves*), 17 ♀♀, 2 ♂♂, xi.1927 (*H. Hargreaves*).

Host. The type series was reared from larvae of *Papilio demodocus*, L., as were those from Uganda bred by Mr. Hargreaves. Apart from the type series, those bred by Mr. Gowdey are without host record, although in all likelihood the series dated 1916 was reared at the same time as the specimens from which the species was described. The series from Kenya is labelled "from *Papilio*, probably *P. demodocus*."

Cocoons. No mention is made of cocoons in the original description, but the cocoons of Mr. Gowdey's series from Bugoma are brown: the series dated 2.viii.1927 has two cocoons, and these are pale. The remaining series unfortunately are without cocoons.

Apanteles fuscinervis, Cam.

Apanteles fuscinervis, Cameron, 1911, Ann. Transv. Mus., 2 : 207.

This species was originally described from a single male from South Africa, Rietfontein, Pretoria District, and the type is in the Transvaal Museum.

Host unknown.

Cocoons unknown.

Through the kindness of the Director of the Transvaal Museum I have been able to examine this unique specimen, and below I give a redescription of it, Cameron's description being almost worthless :—

♂. Black; the four anterior legs (save for portions of their coxae), the hind femora (save for some darkening at extreme apex), the hind tibiae (save for darkening in the apical third), and the tegulae, red testaceous; hind tarsi darkened; palpi and tibial spurs pale, as are to some extent the basal ventrites; the costal veins, stigma, and metacarp, light reddish-brown, as are some of the other wing-veins, many of these latter, however, colourless.

♂. *Head*: frons and vertex (including the ocellar region) with pile so faint and very weak that they appear smooth; occiput with distinctly stronger setae, pruinose; the posterior ocelli apparently rather nearer to the eyes than to each other. *Thorax*: mesonotum regularly and rather closely punctate (degree 3), rather strongly setiferous; disc of scutellum setiferous but the punctures indefinite; propodeon setiferous, indefinitely punctate (degree 2), and with a very weak median longitudinal carina throughout its length save at extreme base. *Wings*: the upper portion of the basal vein short, distinctly shorter than the pigmented portion of the 2nd abscissa of the cubital; the 1st abscissa of the radial and the transverse cubital distinctly angled; metacarp barely longer than stigma. *Legs*: hind coxae almost throughout setiferous and with fairly close minute punctation. *Abdomen*: 1st tergite long, its lateral margins quite straight and regularly converging to the truncate apex, its median length quite twice its basal breadth and quite four times its apical breadth (30 : 14 : 7), slightly turned over and down in the apical two-fifths, slightly excavate medianly in the basal three-fifths, in the apical three-fourths (except where excavate) with indefinite striate punctation; 2nd tergite with its base rather narrower than the apex of the 1st tergite, and with its median length just shorter than its own apical breadth (5 : 7 : 12 : 14), its sulci quite straight and its apex very slightly emarginate, the integument very distinctly longitudinally striate in the lateral thirds, much smoother medianly; 3rd tergite much longer than the 2nd (16 : 12), with but widely and fairly evenly spaced, minute punctation (degree 1); succeeding tergites punctate as the 3rd.

Length, 3 mm.

Apanteles eucosmae, Wilkn.

Apanteles eucosmae, Wilkinson, 1929, Bull. Ent. Res., **20** : 445.

This species was originally described from 22 ♀♀, 7 ♂♂, from NIGERIA and the BELGIAN CONGO, with a further series of 54 ♀♀, 4 ♂♂, from UGANDA, and the type, with numerous cotypes, is in the British Museum.

In addition to the above, this species is also known to me from a series of 113 ♀♀, 38 ♂♂, 12.viii.1929 (*H. Hargreaves*), also from Uganda.

Host. Those of the type series from the Belgian Congo were bred from the Arctiid *Diacrisia mundata*, Walk., while both series from Uganda were also bred from an Arctiid.

Cocoons. The cocoons were originally described as contained within a spherical mass of white fluff, but it is obvious to me now, from this latest series from Uganda, that the cocoon mass can be a shapeless and conglomerate collection with quantities of white fluff.

Apanteles belliger, Wilkn.

Apanteles belliger, Wilkinson, 1929, Bull. Ent. Res., **20** : 107.

This species was originally described from 10 ♀♀, 14 ♂♂, from MAURITIUS, and the type with some cotypes is in the British Museum.

Host. The Army Worm, the Noctuid *Cirphis unipuncta*, Haw.

Cocoons. Apparently solitary (one mounted separately with each specimen), straw-coloured.

Apanteles gowdeyi, Gahn.

Apanteles gowdeyi, Gahan, 1918 (1919), Proc. U.S. Nat. Mus., **54** : 589.

This species was originally described from ten males and females from UGANDA, and the type is in the U.S. Nat. Mus., with one male cotype in the British Museum.

In addition to the above-mentioned cotype, this species is known to the writer from a series of 7 ♀♀, 8 ♂♂, 17.xi.1915 (*C. C. Gowdey*), also from UGANDA.

Host. The type series was bred from an unknown caterpillar.

Cocoons unknown.

Apanteles ugandaensis, Gahn.

Apanteles ugandaensis, Gahan, 1918 (1919), Proc. U.S. Nat. Mus., **54** : 589.

This species was originally described from four females from UGANDA, and the type is in the U.S. Nat. Mus., with one cotype in the British Museum.

Host. A Pyralid on *Hibiscus*.

Cocoons unknown.

Apanteles acraeae, sp. n.

♀♂. Black; the four anterior legs entirely, including the coxae but excluding the feet, hind trochanters and trochantines, the hind femora (except at extreme apex), the hind tibiae (except for the slightly darkened apical fourth), and the tegulae, red testaceous; palpi, tibial spurs, and the basal sternites, pale; hind tarsi as darkened as the apex of the hind tibiae; stigma, metacarp, and wing-veins (except those towards the base of the wing, which are pale to colourless), brown.

♀♂. *Head*: face with regular, minute punctation; the facial depressions nearer to apex of clypeus than to the eyes; the clypeus not differentiated; frons and vertex minutely punctate; the hind ocelli equidistant from each other and the eyes, or rather nearer to each other. *Thorax*: mesonotum with regular, evenly spaced punctation throughout, this anteriorly minute (degree 3), and posteriorly becoming increasingly minute (degree 1); disc of scutellum with some extremely sparse and minute (degree 1) punctation; propodeon smooth entirely save for a few very widely and sparsely placed, weak punctures (degree 3). *Wings*: the breadth of the stigma equal to the length of the 1st abscissa of the radial, which vein is very definitely angled with and 1·5 times as long as the transverse cubital, which latter is rather shorter than the recurrent; the apical portion of the 1st abscissa of the cubital about equal to the pigmented portion of the 2nd abscissa of the cubital, and about equal to or rather longer than the upper portion of the basal vein; stigma shorter than metacarp. *Legs*: hind coxae both basally and apically above, and on the outer faces above, with large areas entirely smooth and entirely devoid even of minute punctation; the hind tibial spurs subequal, the longer spur about half the length of the basal joint of the hind tarsus. *Abdomen*: 1st tergite smooth save for some well-marked (degree 3 or 3–4), distinct, widely separated punctation in the lateral thirds of the apical half, slightly and regularly turned over, its lateral margins parallel in about the basal half, thence roundly evenly contracting to the slightly emarginate apex, the basal breadth of the tergite about two-thirds the median length and rather more than twice the apical breadth; 2nd tergite with a little, indefinite sculpture laterally and apically, its well-marked discal sulci diverging at an angle approaching 90°; 2nd suture bisinuate; 3rd tergite considerably longer than the 2nd (16 : 10), with only the usual minute punctation; hypopygium very slightly acute; ovipositor sheaths short, apparently not or hardly longer than the basal joint of the hind tarsus.

Length, 2–3 mm.

UGANDA: 3 ♀♀, 2 ♂♂, 22.vii.1930, 1 ♂, viii.1930 (*H. Hargreaves*).

Type deposited in the British Museum.

Host. The July series is labelled " ex *Acraea* probably *acerata* on *Ipomaea* sp.," with the serial number D.109; the single male bred in August is definitely labelled as bred from the Nymphalid, *Acraea acerata*, Hew., on sweet potato.

Cocoons of the July series white, of the August specimen tawny yellow. They are very distinctive, having a beautiful, reticulate, dome-like structure of silk over and standing well away from the puparium proper (Pl. XVII, fig. 1). This outer network may possibly be an attempt at protection against parasites: numerous parasites and hyperparasites were bred from this *Apanteles*.

Apanteles maculitarsis, Cam.

Apanteles maculitarsis, Cameron, 1904, Rec. Albany Mus., **1** : 173; Cameron, 1907, Ann. S. Afr. Mus., **5** : 204; Brues, 1924, Ann. S. Afr. Mus., **19** : 145; Brues, 1926, Proc. Amer. Acad. Arts & Sci., **61** : 418.

Apanteles capensis, Cameron, 1907, Ann. S. Afr. Mus., **5** : 203 (*syn. nov.*).

Apanteles testaceolineatus, Cameron, 1911, Ann. Transv. Mus., **2** : 208 (*syn. nov.*).

Apanteles testaceioventris, Cameron, 1911, Ann. Transv. Mus., **2** : 208 (*syn. nov.*).

Apanteles (*Protapanteles*) *africanus*, Viereck (*nec* Cameron), 1911, Proc. U.S. Nat. Mus., **40** : 174 (*syn. nov.*).

This species is known to me from the following material:—The type of Cameron's *A. maculitarsis*, which he described from GRAHAMSTOWN from apparently this single specimen; the type series of *A. capensis*, which consists of 4 ♀♀, 3 ♂♂, and was described from CAPE TOWN; the type of *A. testaceolineatus*, a female, which was described from the TRANSVAAL from apparently this single specimen; the type of *A. testaceioventris*, a male, which was described from the TRANSVAAL from apparently this single specimen; and a female paratype of Viereck's *A.* (*P.*) *africanus*, a species that was described from PRETORIA, TRANSVAAL, from an unstated number of specimens. In addition, I have before me the following series:—SOUTH AFRICA: Boksburg, Transvaal, 23 ♀♀, 1 ♂, vii.1925 (*Rev. D. P. Murray*), Johannesburg, 4 ♀♀, 3 ♂♂, 21.i.1926 (*H. T. Coetzee*), Cape Town, 5 ♀♀, 7 ♂♂, i.1909 (*Lightfoot*), and George, Cape Province, 4 ♀♀, 4 ♂♂, x.1928.

Host. The series dated 21.i.1926 was bred from the Saturniid *Gonimbrasia tyrrhea*, Cram.; that dated i.1909, from the Geometrid, *Osteodes turbulentata*, Guen., from *Acacia horrida*; and that dated x.1928, from larvae of the Saturniid, *Nudaurelia cytherea*, F. The other material is without host record, as are the original descriptions of all the *Apanteles* in the above synonymy.

Cocoons unknown.

Apanteles glyphodes, sp. n.

♀♂. Black; the four anterior legs entirely (except the feet), the hind femora (except at extreme apex), about the basal half of the hind tibiae of the ♀, the hind coxae to some extent at extreme apex, and the tegulae, red testaceous; the palpi, tibial spurs, and the basal sternites together with the lateral membranous margins of the basal tergites, pale to yellowish-testaceous; the stigma, metacarp, and wing-veins uniformly brown.

♀♂. *Head*: face and clypeus with evenly spaced, minute (degree 2) punctation; the clypeus hardly differentiated; the facial depressions rather nearer to apex of clypeus than to the eyes; frons and vertex very sparingly punctate (degree 1); the posterior ocelli about equidistant from each other and the eyes, or rather nearer to each other. *Thorax*: mesonotum shining, regularly punctate, decidedly more closely and more strongly so anteriorly (degree 3), increasingly more weakly and more sparsely so posteriorly; disc of scutellum with only an occasional minute puncture; propodeon smooth save for some widely scattered punctures (degree 3) in the basal half, and for certain striation in the apical half particularly medianly where there is some evidence of an incipient median longitudinal carina. *Wings*: the breadth of the stigma about equal to the length of the 1st abscissa of the radial, which is strongly angled with and longer than the transverse cubital, this latter about equal to the recurrent; pigmented portion of the 2nd abscissa of the cubital equal to or longer than the apical portion of the 1st abscissa of the cubital, which is longer than the upper portion of the basal vein; stigma shorter than metacarp. *Legs*: hind coxae polished, on outer faces with regular, widely spaced, minute punctation (degree 1), basally above with strong (degree 4 or at least 3–4), distinct, separated punctation; the longer hind tibial spur four-sevenths, and the shorter spur just less than half, the length of the basal joint of the hind tarsus. *Abdomen*: 1st tergite with weak striation and/or punctation laterally, and with some weak punctation in the apical fourth, as often almost entirely smooth, its apical fourth turned over, its lateral margins parallel (or sometimes very slightly converging apicad), at extreme apex strongly roundly contracted, the median length of the tergite twice its breadth; 2nd tergite shorter than the 3rd, often with some weak, indefinite striation, its cleanly marked discal sulci, whose angle of divergence is distinctly greater than 45°, rarely quite straight being irregularly decurved, or bent, towards apex; 3rd and succeeding tergites with only the usual minute sparse punctation; hypopygium (as viewed from side) cut away to form a short lower- (in apposition to an upper-) posterior margin that is distinctly obtusely angled with the true lower margin; ovipositor sheaths apparently not, or hardly, longer than the basal joint of the hind tarsus.

Length, 3·0–3·25 mm.

UGANDA: Kampala, 5 ♀♀ (one the *type*), 1 ♂, 1 ?, 18.vii.1923 (*H. Hargreaves*), 16 ♀♀, 3 ♂♂, 1.vii.1929 (*H. Hargreaves*).

Type deposited in the British Museum.

Host. The 1923 series is labelled as bred from the Pyralid, *Glyphodes sericea*, Drury, and the 1929 series from a leaf-roller on " munywamalzi " (!).

Cocoons white, loosely and indiscriminately heaped together.

Apanteles africanus, Cam.

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Apanteles africanus, Cameron (*nec* Viereck), 1911, Ann. Transv. Mus., **2** : 207; Brues, 1924, Ann. S. Afr. Mus., **19** : 145.
Apanteles (*Protapanteles*) *beneficus,* Viereck, 1911, Proc. U.S. Nat. Mus., **40** : 175 (*syn. nov.*).
Apanteles cameroni, Brues, 1924, Ann. S. Afr. Mus., **19** : 145 (*syn. nov.*).

This species was originally described by Cameron from apparently a single female, from SOUTH AFRICA, and the type is the property of the Transvaal Museum. Viereck described his species from an unstated number of specimens of both sexes, from PORTUGUESE EAST AFRICA.

In addition to Cameron's single female (the abdomen of which is missing), this species is known to me from the following series in the British Museum, which were determined as *beneficus* by Muesebeck :—NYASALAND : Mlanje, 3 ♀♀, 25.ii.1913, 7 ♀♀, 4 ♂♂, 4.v.1913, 5 ♀♀, 6 ♂♂, 15.v.1913, 4 ♀♀, 3 ♂♂, 27.viii.1913 (*S. A. Neave*). KENYA COLONY : Kabete, 2 ♀♀, xii.1918 (*T. J. Anderson*).

I have also before me, in addition to the above, the two following series :—UGANDA : 6 ♀♀, undated; 6 ♀♀, 13 ♂♂, 16.iii.1927 (*H. Hargreaves*).

Host. The original descriptions of both *africanus,* Cam., and *beneficus,* Vier., are without host record. The above undated series from Uganda is labelled as having been bred from the larva of a species of the Lymantriid genus *Nygmea,* which is now *Euproctis,* on cotton, and the other series from Uganda from the Lymantriid *Notolophus* (now *Orgyia*) *vetusta,* Hmps.

Cocoons white.

The name *cameroni* was put forward by Brues in place of *africanus,* Cam. Brues rejected *africanus,* Cam., for *africanus,* Vier., naïvely stating that Cameron's paper was undoubtedly later than the paper by Viereck since the particular number of the Annals of the Transvaal Museum was not received in Boston until August. It is, of course, possible that Viereck's paper was the earlier, but Brues has produced no evidence.

GROUP F.

Apanteles sesamiae, Cam.

Apanteles sesamiae, Cameron, 1905–1907, Trans. S. Afr. Phil. Soc., **16** : 335.

This species was originally described from the female only (number not stated) from CAPE COLONY, and the location of the type is not known to the writer.

A. sesamiae is known to me from 4 ♀♀, 2 ♂♂, 26.iii.1919, from Crocodile Poort, TRANSVAAL, that were determined by Dr. C. F. W. Muesebeck, and of which there are now specimens in the British Museum. It is also known to me from the following series, numerous representatives of which are also in the British Museum :—SUDAN : Talodi, 1 ♀, 2 ♂♂, 11.x.1928 (*W. Ruttledge*). UGANDA : Bukalasa, 7 ♀♀, 9.ix.1925 (*G. L. R. Hancock*); Kampala, 26 ♀♀, 2 ♂♂, 20.vii.1929 (*G. L. R. Hancock*); Kampala, 43 ♀♀, 29 ♂♂, 12.viii.1929 (*H. Hargreaves*); Kampala, 9 ♀♀, 1 ♂, 14.ix.1929 (*H. Hargreaves*). NYASALAND : 4 ♀♀, 1 ♂, 1929 (*C. Smee*). KENYA COLONY : Nakuru, 15 ♀♀, 9 ♂♂, 19.i.1931 (*R. H. Le Pelley*).

Host. The type series was bred from the Noctuid cane-borer *Busseola fusca,* Fuller (= *Sesamia fusca,* Hmps.). The Sudan series is labelled as having been bred from *Sesamia cretica,* Led., and that from Nyasaland from a species of the Pyralid genus *Chilo.* Of the Uganda series, that dated 1925 is without host record; that dated vii.1929 is labelled as having been bred from *Busseola fusca* in *Sorghum*; that dated viii.1929, from *B. fusca* in maize stem; and that dated ix.1929, from a caterpillar boring in maize. The series from Kenya was also bred from *Busseola fusca.*

Cocoons, white, solitary or grouped loosely together.

This species is remarkably like *Apanteles flavipes*, Cam. (= *A. nonagriae*, Olliff), and in fact may only be of subspecific rank and the Ethiopian representative of this widely distributed cane parasite of the Orient. It is, however, immediately and very easily separable by means of the punctures of the mesonotum: these in *flavipes* are invariably strong, though widely separated, and in *sesamiae*, invariably minute.

Apanteles neavei, Wilkn.

Apanteles neavei, Wilkinson, 1929, Bull. Ent. Res., **20** : 447.

This species was originally described from 23 ♀♀, 3 ♂♂, from Nyasaland, and the type with numerous cotypes is in the British Museum.

Host unknown.

Cocoons unknown.

Apanteles mlanje, Wilkn.

Apanteles mlanje, Wilkinson, 1929, Bull. Ent. Res., **20** : 449.

This species was originally described from 40 ♀♀, 23 ♂♂, from Nyasaland, and the type with numerous cotypes is in the British Museum.

Host unknown.

Cocoons unknown.

Apanteles mlanje nigricoxis, subsp. n.

♀♂. Agrees in colour with the description of *Apanteles mlanje*, Wilkn., except as follows :—All coxae black except beneath at apex where they are to a variable extent red testaceous; extreme apices of hind femora, hind tarsi, darkened; apical half of hind tibiae strongly darkened to black; tegulae black; stigma and all wing-veins brown; wings decidedly infumated.

♀♂. Agrees well enough with the description of the sculpture and structure of *A. mlanje*, Wilkn., except as follows : *Abdomen* : 2nd tergite with median converging sulci finely rugose and less definitely marked, the fine rugosity spreading, particularly basally, on to the lateral areas of the tergite, and with the median area not so broad at base as in *mlanje* and rarely if at all smooth; 3rd tergite more distinctly marked with fine rugosity laterally at extreme base.

Uganda : Kampala, 3 ♀♀, 1 ♂, viii.1929 (*G. L. R. Hancock*).

Type deposited in the British Museum.

Host unknown.

Cocoons greenish-yellow, heaped together as in *glomeratus.*

It might be suggested that the original description of *A. mlanje* was drawn up from immature specimens whose coxae and wings had not had sufficient time in which to darken. I do not think that this is so: every specimen appears to me to be quite mature without even suspicion of any darkening of the coxae.

Apanteles chrysippi, Vier.

Apanteles (*Protapanteles*) *chrysippi*, Viereck, 1911, Proc. U.S. Nat. Mus., **40** : 175.

This species was originally described from an unstated number of both males and females from PORTUGUESE EAST AFRICA, and the type is in the United States National Museum.

A. chrysippi is known to me only from a series of 3 ♀♀, and 1 of indeterminable sex, from Pretoria, TRANSVAAL, that was determined by Dr. C. F. W. Muesebeck, and of which there are now representatives in the British Museum.

Host. Both the type series and the above series from the Transvaal were bred from larvae of the cosmopolitan Danaid butterfly *Danais chrysippus*, L.

Cocoons unknown.

Apanteles ruficrus, Hal.

Microgaster ruficrus, Haliday, 1835, Ent. Mag., **2** : 253.

Apanteles ruficrus, Haliday, Reinhard, 1880, Deuts. ent. Z., **24** : 368; Marshall, 1885, Trans. Ent. Soc. Lond., **1885**: 166; Marshall, 1889, in Andre, Hym. d'Eur. d'Alg., **4** : 410; 1898, **5** bis : 177; Gahan, 1928, Bull. Ent. Res., **19** : 256; Wilkinson, 1929, Bull. Ent. Res., **20** : 108.

Apanteles antipoda, Ashmead, 1900, Proc. Linn. Soc. N.S. Wales, **25** : 355; Wilkinson, 1928, Bull. Ent. Res., **19** : 95; 1929, **20** : 108.

Apanteles manilae, Ashmead, 1904, J.N.Y. Ent. Soc., **12** : 19 (nec *Glyptapanteles manilae*, Ashm. 1905).

Apanteles sydneyensis, Cameron, 1911, Proc. Linn. Soc. N.S. Wales, **36** : 342.

Apanteles (*Protapanteles*) *narangae*, Viereck, 1913, Proc. U.S. Nat. Mus., **44** : no. 1974 : 642.

This species was originally described from apparently a single female from presumably the British Isles, and the location of the type is at present unknown.

The species that is now generally accepted as *ruficrus*, Hal., would appear to be cosmopolitan and is known to me from the Ethiopian region from the following series, various representatives of which are in the British Museum :—SUDAN : Khartoum, 4 ♀♀, 1 ♂, 2.xii.1926 (*H. B. Johnston*), 1 ♀, 1 ♂, 28.xi.1928 (*R. C. Darling*). UGANDA : Kampala, 7 ♀♀, 17.xi.1915 (*C. C. Gowdey*), 28 ♀♀, 10 ♂♂, 6.vii.1929 (*H. Hargreaves*). ITALIAN SOMALILAND : 3 ♀♀, 1 ♂, 27.ii.1926 (*Paoli*), 2 ♀♀, 1 ♂, viii.1926 (*Paoli*), 3 ♀♀, i.1926 (*Paoli*).

Host. The type is without host record, of course. Of the Ethiopian material recorded above, Darling's two specimens were bred from the Noctuid *Cirphis loreyi*, Dup., and Paoli's material dated ii. and viii.1926 is labelled to have been bred also from this host. Paoli's other specimens are labelled "ex ? *Sesamia calamistis*," while Johnston's material is labelled as parasitic on a "Lepidopterous borer in *Pennisetum*." Dr. Gahan has recorded *ruficrus* from a borer, probably *Sesamia cretica*, Led., from the Sudan.

Cocoons apparently either solitary or indiscriminately heaped together.

Apanteles flagellator, Wilkn.

Apanteles flagellator, Wilkinson, 1930, Bull. Ent. Res., **21** : 153.

This species was originally described from 15 ♀♀, 4 ♂♂, from UGANDA, and the type with various cotypes is in the British Museum.

Host unknown.

Cocoons unknown.

Apanteles paludicolae, Cam.

Apanteles paludicolae, Cameron, 1909, Spol. Zeylan., **6** : 41; Wilkinson, 1928, Bull. Ent. Res., **19** : 98; Wilkinson 1929, Bull. Ent. Res., **20** : 109.

Apanteles platyptiliae, Cameron, 1909, Spol. Zeylan., **6** : 41; Wilkinson, 1928, Bull. Ent. Res., **19** : 98.

This species was originally described from three females, and the synonym *platyptiliae* from a male and a female, all from Ceylon, and these types are in the British Museum.

A. paludicolae is known to me also in the Ethiopian region from a series from the ANGLO-EGYPTIAN SUDAN of 14 ♀♀, 20 ♂♂, many examples of which also are now in the British Museum.

Host. Cameron's material was bred from larvae of the Pterophorid moths *Trichoptilus paludum*, Zell. (=*paludicola*, Fletcher) and *Platyptilia molopias*, Meyr., and that from the Sudan from the Pterophorid *Sphenarches caffer*, Zell.

Cocoons white.

GROUP U.

Apanteles trochanteratus, Szép.

Apanteles trochanteratus, Szépligeti, 1911, Wiss. Ergebn. deuts. Z. Africa Exp., **3** : 412.

This species was originally described from a single female from TANGANYIKA TERRITORY, and the type is in the Zoological Museum, Berlin.

Host unknown.

Cocoons unknown.

Through the kindness of the Director of the Zoological Museum, Berlin, I have been able to examine this unique specimen, and below I give a redescription of it :—

♀. Black; scape except at apex, tegulae, the four anterior legs, hind coxae at apex, hind trochanters and trochantines, hind femora, 3rd tergite, the lateral membraneous margins of the basal tergites, the ventrites mostly, red testaceous; flagellum, hind tibiae and tarsi, brown; palpi and tibial spurs pale; stigma and wing-veins brown, the costal vein more or less testaceous; wings slightly infumated.

♀. *Head* : face punctate (degree 2); clypeus not differentiated; facial depressions nearer to the apex of the clypeus than to the eye; the posterior ocelli apparently equidistant from one another and from the eye. *Thorax* : mesonotum with strong, well-separated punctures (degree 4–5), in no part even approaching rugose or striate, the lines of the notauli completely absent; disc of scutellum to some extent punctate (degree 3–4) basally and along the sides, the punctures widely separated, otherwise smooth, flat, level with the mesonotum, the scutellar depression curved; propodeon coarsely reticulate-rugose in apical half, closely rugose right across the base, the areola well marked, shining, indefinitely sculptured, the areolar carinae well marked except in base; the presence or absence of costulae indeterminable. *Wings* : the breadth of the stigma 1·33 times the length of the 1st abscissa of the radial, this latter about equal to the recurrent, which is a little longer than the transverse cubital; the apical portion of the 1st abscissa of the cubital apparently equal to the pigmented portion of the 2nd abscissa, about two-thirds the length of the transverse cubital, much longer than the upper portion of the basal vein; stigma shorter than metacarp. *Legs* : hind coxae highly shining, on outer faces punctate (degree 3–4), the punctures unusually shallow, basally above with some strong (degree 5), well-separated, and well-impressed punctation; the hind tibial spurs subequal, rather less than half the length of the basal joint of the hind tarsus. *Abdomen* : 1st tergite with median length 1·22 times apical breadth, this latter only just less than the greatest breadth (36 : 38) and only somewhat greater than the basal breadth (36 : 32), with the greatest breadth almost at apex, with the lateral margins straight, with the apex slightly emarginate but straight in each lateral half, the lateral corners not or hardly rounded, and with the integument rugose or rugose reticulate, medianly slightly tumescent, with a semicircular smooth shining area at middle at extreme apex; 2nd tergite rugose, basally as broad as, and conforming with the shape of, the apex of the 1st tergite, apically strongly and evenly rounded, with the apical breadth about equal to the median length of the 1st tergite, and about 3·66 times its own median length, the lateral sulci well marked as is the 2nd suture; 3rd and succeeding tergites smooth; ovipositor sheaths apparently rather longer than the hind tarsus.

Length, 3 mm.

Apanteles sagax, Wilkn.

Apanteles sagax, Wilkinson, 1929, Bull. Ent. Res., **20** : 111.

This species was originally described from 8 ♀♀ (one the *type*), 1 ♂, from TANGANYIKA TERRITORY, and 32 ♀♀, 4 ♂♂, from UGANDA, and the type with various cotypes is in the British Museum.

Host. Both series were bred from the Pyralid *Sylepta derogata*, F.

Cocoons unknown.

GROUP S.

Apanteles hylas, sp. n.

♀. Black; the four anterior legs, the coxae, trochanters, trochantines, and femora of the hind legs, the basal third of the hind tibiae, the tegulae, large portions of the scape, and the ventrites, red testaceous; apical two-thirds of the hind tibiae, the hind tarsi, darkened; palpi and tibial spurs pale; wings slightly infumated; the stigma, metacarp, and the veins in the medial portion of the wing, brown; stigma basally with a cloud; costal veins red testaceous in at least the basal half.

♀. *Head* : face and clypeus evenly and rather closely punctate (degree 2); the clypeus not differentiated; facial depressions rather nearer to apex of clypeus than to the eyes; face medianly above with quite a distinct longitudinal carina; vertex and occiput more or less pruinose; posterior ocelli equidistant from each other and the eyes. *Thorax* : mesonotum virtually throughout with closely placed, regular, strong punctation (degree 4); disc of scutellum with the same type of punctation as on the mesonotum but shallower, and down the middle indefinite; propodeon with some strong punctures and some coarse rugosity basally to the areola and costulae, in the areola and beyond the costulae rarely punctate and with only weak sculpture and often entirely smooth; the areola closed at base, obliquely quadrate (diamond-shaped), its basal margins in a continuous straight line with their respective oblique costulae, and the apex of the areola broadly V-shaped; the carinae of the areola not clean but rugose, the apical carinae distinctly weaker than the basal plus costulae. *Wings* : the straight transverse cubital with its point of junction with the evenly rounded 1st abscissa of the radial hard to determine, equal in length to the recurrent, longer than the apical portion of the 1st abscissa of the cubital, twice as long as the pigmented portion of the 2nd abscissa of the cubital, which is equal to the upper portion of the basal vein; stigma shorter than metacarp. *Legs* : hind coxae on outer faces minutely and very sparsely punctate, and with large areas entirely smooth, basally above with a large area with quite strong punctation (degree 3 or 3–4); the longer hind tibial spur about three-fifths, and the shorter spur about two-fifths, the length of the basal joint of the hind tarsus. *Abdomen* : 1st tergite rugose, tumescent, with median length barely greater than apical breadth and 1·5 times basal breadth (24 : 22 : 16), the lateral margins evenly diverging and virtually straight, the apical angles not rounded, the apical margin very slightly emarginate; the tergite narrowly across its extreme apex suddenly flattened so as to be on the same plane as the 2nd tergite, this flattening much emphasising the general tumescent rotundity; 2nd tergite rugose but rather more weakly than in the 1st, transverse, virtually rectangular, its lateral margins being parallel, its apex, however, slightly and evenly rounded (concavity basad), with its median length rather less than half its breadth and equal to the median length of the 3rd tergite (9 : 20 : 9); 2nd suture broad, deep, weakly crenulate;

3rd tergite with some weak sculpture basally, otherwise as the succeeding tergites smooth save for the usual minute punctation; ovipositor sheaths about equal to the combined length of the two basal joints of a hind tarsus.

Length, 2 mm.

South Africa : Mossel Bay, Cape Province, 3 ♀♀, iv.1921 (*type*), viii.1921, xii.1921 (*R. E. Turner*).

Type in the British Museum.

Host unknown.

Cocoons unknown.

Apanteles eros, sp. n.

♀. Black; tegulae, the four anterior legs, the hind femora, trochanters and trochantines, and the abdominal ventrites, invariably red testaceous; hind coxae more usually completely red testaceous, occasionally however with some darkening on the outer faces, and very occasionally (2) completely black; hind tibiae red testaceous with the extent of the apical darkening varying from only at extreme apex to apical two-fifths; hind tarsi darkened; scape variable between red testaceous and black, and intermediately; mesonotum almost invariably red testaceous, very rarely completely black, occasionally with median and lateral longitudinal black streaks, more rarely with black patches; disc of scutellum either red testaceous or black, rather more usually the former; the mesopleurae rarely entirely black, more usually red testaceous with narrow black marking above, occasionally only red testaceous immediately below the tegulae; the 1st tergite usually black, very occasionally red testaceous; 2nd tergite red testaceous rather more often than in the 1st; 3rd tergite more often red testaceous than black; succeeding tergites rarely black; palpi and tibial spurs pale; wings infumated; wing-veins, stigma, and metacarp, brown, the costal veins to some extent red testaceous basally.

♂. Black; tegulae, the four anterior legs (except as follows), the hind femora, trochanters and trochantines, invariably red testaceous; the middle coxae occasionally partly darkened or even black, as are also sometimes the front coxae, but more rarely so; middle tarsi occasionally slightly darkened; hind tibiae red testaceous with the extent of the apical darkening varying from only at extreme apex to apical three-fifths, but more usually only about the apical third, this darkening sometimes quite strong; hind tarsi sometimes quite strongly darkened, always at least slightly so; hind coxae invariably black; scape black, but often particoloured with both red testaceous and black; mesonotum more usually (10) entirely black, often however (7) with some little red testaceous colouring, nearly as often (6) largely red testaceous with some little black, sometimes (5) patched with an equal quantity of black and red testaceous, never (0) entirely red testaceous; the mesopleurae more usually entirely black (20), occasionally (8) red testaceous just below the tegulae; the ventrites generally with some red testaceous colouring, as are also sometimes the mouthparts; palpi and tibial spurs pale; wings infumated; wing-veins, stigma, and metacarp, brown, the costal veins largely red testaceous.

♀♂. *Head* : clypeus, face, frons laterally, with evenly spaced minute (degree 1) punctation; vertex with minute and more widely spaced punctures; the occiput more or less pruinose; facial depressions much nearer to apex of clypeus than to the eyes; clypeus to some extent differentiated; posterior ocelli equidistant from each other and the eyes. *Thorax* : mesonotum punctate (degree 2–4) but the strength and quantity of the punctures variable, in some specimens anteriorly the punctures so close as to give a rugose effect, generally the punctures stronger and closer anteriorly, invariably the punctures regular; disc of scutellum with scattered punctation; propodeon punctate (degree 3–4) basally to the costulae, impunctate in the areola and apically to the costulae; the costulae horizontal or even slightly up-turned, emitted from slightly beyond the middle of the areola; the areola longer than broad (about 10 : 7), truncate both apically and basally, invariably margined with carinae only beyond the costulae, basally to the costulae with its margins delimitated variably and in varying strength and extent either by a broken, intermittent series of raised rugosities, or by a line of close, rugose punctures, or even not at all delimitated save by the absence of punctation, in some cases however the areola delimitated throughout by clean carination. *Wings*: the recurrent usually equal to the transverse cubital and rather shorter than the 1st abscissa of the radial, this latter four-fifths the breadth of the stigma and 1·5 times as long as the apical portion of the 1st abscissa of the cubital; upper portion of the basal vein usually about as long as the pigmented portion of the 2nd abscissa of the cubital and about half the length of the recurrent; all parts very variable however so that the upper portion of the basal vein occasionally equals or is greater than the apical portion of the 1st abscissa of the cubital, and the recurrent is longer than the transverse cubital; 1st abscissa of the radial either slightly angled with, or sometimes evenly rounded with, the transverse cubital; stigma shorter than metacarp. *Legs*: hind coxae on outer faces polished and with but few and very sparsely placed minute punctures, above minutely punctate, and basally above with indication of some rather stronger punctation; the longer hind tibial spur one-half, and the shorter spur rather more than one-third, the length of the basal joint of the hind tarsus. *Abdomen*: 1st tergite at least in apical half either minutely rugose, aciculate, or minutely sculptured, and with some distinct punctures (degree 3), slightly turned over, medianly slightly tumescent, apically slightly emarginate and with its apical angles not rounded, with its median length 1·6 times its median breadth, and its lateral margins parallel in the ♀ and slightly contracted apically in the ♂; 2nd tergite transverse, considerably shorter than the 3rd, aciculated throughout, and with lateral sulci which are oblique at least basally, the tergite in the ♂ not so strongly transverse and rather longer than in the ♀; 3rd tergite smooth and polished, as are the succeeding tergites, with but widely spaced, regular, minute (degree 1) punctation; ovipositor sheaths clearly shorter than a hind tarsus, about equal to the two basal joints of a hind tarsus.

Length, 2·0–2·5 mm.

SOUTH AFRICA: Mossel Bay, Cape Province, 5 ♂♂, iv.1921, 1 ♂, vi.1921, 3 ♀♀, 7 ♂♂, 5–31.vii.1921, 3 ♀♀, 4 ♂♂, viii.1921, 3 ♂♂, x.1921, 3 ♀♀, 3 ♂♂, 1–14.xi.1921, 3 ♀♀ (one the *type*), xii.1921, 1 ♀, iii.–iv.1930, 1 ♀, 1 ♂, vi.–vii.1930 (*R. E. Turner*); Camps Bay, Cape Peninsula, 1 ♀, ix.1920, 1 ♂, 1–20.x.1920 (*R. E. Turner*); Aliwal North, Cape Province, 1 ♀, 1 ♂, xii.1922 (*R. E. Turner*); Port St. John, Pondoland, 1 ♂, 5–20.iv.1923, 1 ♂, v.1924 (*R. E. Turner*).

Type in the British Museum.

Host unknown.

Cocoons unknown.

A species with considerable individual variation, but nevertheless with a general facies remarkably uniform.

Apanteles fuscicornis, Cam.

Urogaster fuscicornis, Cameron, 1910, Z. Naturw., **81** : 449.

This species was originally described from apparently a single female from CAPE COLONY, Delagoa Bay, and the type is in the Zoological Museum, Berlin.

Host unknown.

Cocoons unknown.

Through the kindness of the Director of the Zoological Museum, Berlin, I have been able to examine this unique specimen, and below I give a redescription of it, Cameron's description being in many respects grossly inaccurate :—

♀. Black; front legs entirely, middle legs entirely (save for certain darkening of the coxae), the trochanters of the hind legs, and the hind coxae at apex below to some extent, the labrum and the mouthparts generally, the tegulae and costal veins, red testaceous; the trochantines, femora, tibiae, and tarsi of the hind legs *missing*, but these according to Cameron of the same colour as the rest of the legs; antennae, stigma, and metacarp, red-brown; palpi pale; wings hyaline, the majority of the veins colourless.

♀. *Head*: face and clypeus with regular, fairly close, but rather indefinite punctation (degree 2); the facial depressions distinctly nearer to apex of clypeus than to the eyes; clypeus not differentiated; frons laterally distinctly striated; vertex punctate as the face; occiput minutely rugose; posterior ocelli rather nearer to each other than to the eyes. *Thorax*: mesonotum *pierced by pin*, apparently with close punctation (degree 3) and with the lines of the notauli distinct and striato-punctate; disc of scutellum with just a few punctures (degree 2); mesopleurae with a long, broad, fairly deep sulcus, which has irregular, transverse striation (weak carination), anteriorly to which sulcus the mesopleurae are closely punctate (degree 3–4), and posteriorly shining and almost entirely smooth; propodeon with the carinae of the areola and the costulae strong, its sculpture both in the areola and basally to the costulae indefinite, save medianly between the base of the areola and that of the propodeon where it is distinctly broadly rugose, beyond the costulae shining and smooth; the areola very broadly U-shaped, basally distinctly closed by a slightly rounded carina or carinae (concavity apicad), its breadth across the base, which is its greatest breadth, decidedly greater than its median length, this latter in turn longer than the costulae (14 : 10 : 8). *Wings*: the 1st abscissa of the radial angled with and 1·4 times as long as the transverse cubital, which is as long as the recurrent and slightly longer than the apical portion of the 1st abscissa of the cubital, the length of this latter being half the breadth of the stigma and slightly longer than both the upper portion of the basal vein and the pigmented portion of the 2nd abscissa of the cubital, which latter two are equal; the breadth of the stigma 1·8 times the length of the transverse cubital, its length being decidedly less than that of the metacarp; the distance from the point of emission (base) of the radial to the point of junction of the transverse cubital with the cubital vein is greater than the breadth of the stigma. *Legs*: the hind coxae above throughout minutely rugose, and below this rugosity high up on the outer faces with fine, oblique striation; outer faces otherwise with but an occasional puncture. *Abdomen*: 1st tergite rugose and with a strong median tumescence, strongly turned over and down, and with a raised, entirely smooth and highly shining lunule in the middle of the apical margin, its lateral margins diverging in about the basal half and more or less parallel in the apical half, its apical angles not (or but extremely slightly) rounded, the apex slightly emarginate, the median length of the tergite about 1·3 times its apical breadth (34 : 26); 2nd tergite coriaceous in the basal half, longitudinally striate in the apical half, its median length greater than half that of the 3rd (9 : 14); 3rd and succeeding tergites with only the usual minute punctation; hypopygium membranously acute; ovipositor sheaths equal to the combined lengths of a middle tibia and the two basal joints of a middle tarsus.

Length, 3·3 mm.

A species so remarkably like *carpatus* (Say), Gahn., of which the British Museum possesses some specimens, that at the moment I am unable to separate them.

Apanteles diparopsidis, Lyle.

Apanteles diparopsidis, Lyle, 1927, Bull. Ent. Res., **17**: 415; Wilkinson, 1928, Bull. Ent. Res., **18**: 394.

This species was originally described from 2 ♀♀, 1 ♂, from the TRANSVAAL, and the type together with the single male cotype is in the British Museum.

In addition to the above, this species is also known to me from the following series, numerous representatives of which are now also in the British Museum :—NIGERIA: Ibadan, 13 ♀♀, 14 ♂♂, 18.ix.1924, 20.ix.1924, 18.xi.1924, 18.xi.1925

(*A. W. J. Pomeroy*). UGANDA : Kampala, 2 ♀♀, 1 ♂, 1926, 5 ♀♀, 2 ♂♂, xi.1929 (*G. L. R. Hancock*), 4 ♀♀, 5 ♂♂, 30.ii.1929 (*A. B. Killick* per *G. L. R. Hancock*). ZULULAND : Ntambanana, 1 ♀, iv.1930 (*J. S. Taylor*). NORTHERN RHODESIA : Mazabuka, 4 ♀♀, 2 ♂♂, 14–28.ix.1931 (*A. M. Altson*).

Host. The type series was bred from the Red Boll-worm, *Diparopsis castanea*, Hmps., while the single specimen from Zululand is labelled to have been bred from this host also. The series from Uganda dated 1926 was bred by Mr. Hancock from the Gelechiid *Platyedra erebodoxa*, Meyr. The series from Uganda dated 30.ii.1929 is labelled "ex *Earias biplaga*," while that dated xi.1929 is labelled "ex *Earias* sp.," as is also the series from Nigeria. Of the specimens from N. Rhodesia some are labelled "ex *Earias* spp. larva in early stage," and others as a parasite of young larvae of "*Earias insulana* and *Earias* spp."

Cocoons white and, where occurring in any number, heaped indiscriminately together.

Apanteles coffea, Wilkn.

Apanteles coffea, Wilkinson, 1930, Bull. Ent. Res., **21** : 277.

This species was originally described from 7 ♀♀, 6 ♂♂, from UGANDA, and the type with some cotypes is in the British Museum.

Host. In coffee berries, probably the Tortricid *Argyroploce* (= *Enarmonia*) *batrachopa*, Meyr., but possibly the Pyralid *Thliptoceras octoguttalis*, Felder; in berries of *Tricolysia* sp., definitely the Pyralid.

Cocoons white.

Apanteles coxalis, Szép.

Apanteles coxalis, Szépligeti, 1911, Wiss. Ergebn. deuts. Z. Africa Exp., **3** : 413.

This species was originally described from a single female from TANGANYIKA TERRITORY, and the type is in the Zoological Museum, Berlin.

Host unknown.

Cocoons unknown.

Through the kindness of the Director of the Zoological Museum, Berlin, I have been able to examine this unique specimen, and below I give a redescription of it :—

♀. Black; mouthparts, tegulae, the four anterior legs, the hind trochanters and trochantines, basal two-fifths of the hind femora, basal three-fifths of the hind tibiae, the three basal sternites, lateral membraneous margins of the basal tergites, the 3rd tergite in the lateral thirds, red testaceous; flagellum and hind tibiae dark brown; stigma and wing-veins brown, the costal veins testaceous towards base; hind tibial spurs white.

♀. *Head* : face evenly punctate (degree 2); clypeus emarginate, faintly but distinctly differentiated from the face; facial depressions large, elongate, twice as long as broad, just a little nearer to the eye than to the apex of the clypeus; posterior ocelli nearer to one another than to the eye. *Thorax* : mesonotum with strong, well-separated punctures (degree 4) which however are often shallow and indefinite, rugose along the lines of the notauli; disc of scutellum aciculate along the sides, smooth medianly; propodeon with areola acutely U-shaped (nearly V-shaped) at apex, and closed at base, with its carinae strong; costulae very strong; integument shining and otherwise unsculptured save for irregular, often weak and rather indefinite, secondary carination; medianly at the extreme base the propodeon is excavate somewhat, this area rimmed on each side by a carina and at its apex by the transverse basal carina of the areola. *Wings* : 1st abscissa of radial in length equal to the breadth of the stigma, longer than the recurrent which is 1·5 times as long as the apical portion of the 1st abscissa of the cubital, this latter shorter than the transverse cubital; pigmented portion of the 2nd abscissa of the cubital half the length of the recurrent, longer than the upper portion of the basal vein; stigma much shorter than metacarp. *Legs*: hind coxae above finely rugose and dull, on outer faces above with numerous fine carinae; the longer hind tibial spur half, and the shorter spur about one-third, the length of the basal joint of the hind tarsus. *Abdomen*: 1st tergite about as broad at base as at apex, parallel-sided in the basal fourth, thence gradually widening to the widest point (which is at about the base of the apical fourth) and then gradually narrowing to the truncate apex, with greatest breadth 1·36 times as broad as the apex, and with length rather more than twice apical width, with fine rugulose longitudinal carinae throughout, medianly strongly tumescent, in apical third somewhat excavate in the middle, and at middle of extreme apex with a smooth shining semicircular area; 2nd tergite with numerous fine rugulose longitudinal carinae and strongly chitinised as the 1st tergite so that its shape is well marked, with straight diverging sides and with apex strongly rounded, at base just narrower than apical breadth of 1st tergite, the sides in length half the basal breadth and just shorter than the median length, and with the greatest breadth 1·5 times the basal breadth; 2nd suture well marked but fine; 3rd tergite with median length equal to the basal breadth of the 2nd tergite, smooth and unsculptured as are all succeeding tergites; ovipositor sheaths shorter than hind femora but very definitely longer than the basal joint of the hind tarsus.

Length, 3 mm.

Apanteles earterus, Wilkn.

Apanteles earterus, Wilkinson, 1930, Bull. Ent. Res., **21**: 278.

This species was originally described from 12 ♀♀, 6 ♂♂, from the ANGLO-EGYPTIAN SUDAN, and the type with various cotypes is in the British Museum.

Host. The Noctuid moths, *Earias insulana*, Boisd., and *Diparopsis castanea*, Hmps.

Cocoons white.

Apanteles afer, sp. n.

♀. Black; the front femora (except for about basal third to a half), the anterior tibiae and tarsi except that the feet are darkened, about the basal fourth or third of the hind tibiae, and the extreme base of the basal joint of the hind tarsus, red testaceous; palpi and tibial spurs pale; wings very slightly, evenly infumated; the stigma, which is uniformly opaque, the wing-veins, and the metacarp, brown.

♂. Agrees with the above colour description of the female except as follows:—the middle tibiae testaceous only basally, and the hind tibiae only in about the basal fifth; stigma and metacarp uniformly opaque brown; the wing-veins otherwise (save for the costal veins, and for the transverse cubital and veins in its immediate neighbourhood, which have a little pigmentation) colourless; the wings pellucid hyaline.

♀♂. *Head* minutely (degree 1) and evenly punctate throughout, save that the occiput is minutely rugose; facial depressions somewhat nearer to apex of clypeus than to eyes, but not distinctly so; clypeus only somewhat differentiated; the posterior ocelli very distinctly closer to each other than to the eyes. *Thorax* much compressed dorso-ventrally; mesonotum, disc of scutellum, and the propodeon anteriorly, virtually in one plane; mesonotum shining, with minute (degree 2), evenly spaced, and very definitely separated punctation, the lines of the notauli entirely wanting; medianly in the posterior fourth of the mesonotum, immediately anterior to the scutellar sulcus, is some distinct, but very fine, longitudinal striation; the scutellar sulcus in the ♀ slightly and evenly arcuate, composed of nine shallow, small, cleanly sculptured crenulations, in the ♂ biarcuate, each arc slight and even, each with from six to eight crenulations of the same nature as in the ♀ (making a total of usually 15 crenulations for the complete sulcus), a distinctly larger crenulation in the middle of the complete sulcus joining (or separating) these two arcs; disc of scutellum very flat, smooth, highly shining, with only an occasional minute (degree 1) puncture; posterior polished area on lateral faces of scutellum large, more or less triangular, and reaching quite two-thirds of the way up towards the scutellar sulcus; propodeon unusually flattened, more or less dull, with numerous fine striae and carinulae; costulae and areola almost invariably well marked, the latter elongate (very definitely longer than greatest breadth) and reaching from apex of propodeon almost to base; the areola apically acutely V-shaped, closed at base with its basal angle about 90°. *Wings*: ♀—in one specimen the breadth of the stigma equal to the length of the recurrent, which is just shorter than the 1st abscissa of the radial and just longer than both the transverse cubital and the apical portion of the 1st abscissa of the cubital; in the other specimen the breadth of the stigma, and the length of the 1st abscissa of the radial, the transverse cubital, and the recurrent, all equal, just longer than the apical portion of the 1st abscissa of the cubital; the lengths relative to each other, therefore, of the 1st abscissa of the radial and the transverse cubital variable; these two latter veins distinctly angled; pigmented portion of the 2nd abscissa of the cubital equal to the upper portion of the basal vein; metacarp considerably longer than stigma; in the ♂ the venation not so variable, the breadth of the stigma, the transverse cubital, and the apical portion of the 1st abscissa of the cubital equal, shorter than the recurrent which is shorter than the 1st abscissa of the radial, this latter being 1·4 times as long as the breadth of the stigma; 1st abscissa of radial distinctly angled with transverse cubital; metacarp very considerably longer than stigma. *Legs*: hind coxae above striate and aciculate throughout; the longer hind tibial spur half, and the shorter spur two-sevenths, the length of the basal joint of the hind tarsus; the femora of the ♀, particularly the hind femora, much shorter and stouter than is normal. *Abdomen*: 1st tergite varying from shining and nearly smooth, to dull and minutely rugose, more usually dull and minutely rugose in about the basal three-fourths with the apical fourth more shining and smoother, in the ♀ the tergite narrow and elongate, with parallel lateral margins that contract somewhat only in the apical fourth, so that the median length of the tergite is nearly three times its median breadth and more than three times its apical breadth (16 : 6 : 5), in the ♂ more robust with the lateral margins more bisinuate than parallel, the median length not quite twice the greatest breadth and not quite three times the apical breadth (16 : 9 : 6), in both sexes with the apex strongly emarginate; 2nd tergite smooth, of unusual form for this section of the genus, having discal sulci, these but slightly divergent in the greater part but more widely so at extreme apex, so that the apical breadth of the tergite is twice its basal breadth, approaching twice its median length, and equal to the median length of the 3rd tergite (14 : 7 : 9 : 14); 3rd and succeeding tergites with but very few, sparse, minute punctures; ovipositor sheaths stout, equal in length to the basal joint of the hind tarsus.

Length, 2·25 mm.

UGANDA: Kampala, 2 ♀♀, 6.xii.1930 (*type*), 3.i.1931, 3 ♂♂, i.1931, 10.x.1931 (*H. Hargreaves* and *G. L. R. Hancock*).

Type deposited in the British Museum.

Host. The specimen selected as the type is labelled "on maize leaf," and the other female "ex flat-headed caterpillar leaf-tier on *Pennisetum*." One of the males is labelled "ex ? flat-headed caterpillar on *Pennisetum*," and the remaining two males "ex caterpillar on elephant-grass."

Cocoons white and rather elongate.

A species of unusual form and combination, particularly for this section of the genus.

Apanteles langerburgensis, Szép.

Apanteles langerburgensis, Szépligeti, 1911, Wiss. Ergebn. deuts. Z. Africa Exp., 3 : 412.

This species was originally described from eight specimens from TANGANYIKA TERRITORY, and the type is in the Zoological Museum, Berlin.

Host unknown.

Cocoons unknown.

Through the kindness of the Director of the Zoological Museum, Berlin, I have been able to examine a male and a female of this species, both of which were labelled as type, and below I give a redescription :—

♀♂. Black; the front legs (except the femora somewhat at base, and the coxae and trochanters), middle tibiae and tarsi, basal fourth of hind tibiae, red testaceous; palpi and tibial spurs pale to white; costal veins testaceous; stigma and metacarp dark brown.

♀♂. *Head*: face indefinitely punctate; clypeus emarginate, faintly but distinctly differentiated from face; facial depressions somewhat nearer to apex of clypeus than to the eye; posterior ocelli rather nearer to the eyes than to one another. *Thorax*: mesonotum anteriorly with close, rather fine, almost rugose punctation, posteriorly, at the sides with separated punctures (degree 3), medianly striate or rugoso-striate; disc of scutellum aciculate or striate along the sides, smooth medianly; propodeon with areola V-shaped at apex and more or less closed at base by a straight transverse carina much weaker than the other carinae; costulae hardly stronger than the carinae of the areola; a depressed rimmed area at base of propodeon in middle as in *A. coxalis*; otherwise the integument of the propodeon basally faintly rugose and dull, apically shining, with indefinite rugulae, with the areola smooth and shining. *Wings*: the 1st abscissa of the radial equal to the recurrent, longer than the breadth of the stigma, this latter twice as long as the transverse cubital; the apical portion of the 1st abscissa of the cubital longer than the transverse cubital, 1·5 times as long as the pigmented portion of the 2nd abscissa of the cubital, twice as long as the upper portion of the basal vein; stigma rather shorter than metacarp. *Legs*: hind coxae in upper half rugulose and dull; the longer hind tibial spur half, and the shorter spur about two-sevenths, the length of the basal joint of the hind tarsus. *Abdomen*: 1st tergite strongly rugose and medianly tumescent, with at middle at extreme apex a smooth, semicircular, shining area, in the ♀ gradually widening from base to the broadest point (18 : 22), which is in the apical fourth, thence slightly narrowing to the truncated apex, which latter is apparently a little broader than the base (20 : 18), with the median length twice the basal breadth, in the ♂ with the median length about twice the greatest breadth, and the basal and apical breadths relatively rather narrower than in the ♀; 2nd tergite in the ♀ coriaceous, with some indefinite punctation in apical half, with the apical breadth 1·5 times as long as the basal breadth, this latter equal to the apical breadth of the 1st tergite, the sides straight, strongly impressed, diverging, their length equal to the median length, this latter nearly half as long as the basal breadth of the tergite, the apex pointed in the middle with each lateral half slightly emarginate, in the ♂ indefinitely sculptured except in the middle which is smooth, the median length about half the apical breadth, this latter 2·5 times the length of the straight, diverging, strongly impressed sides, and 1·6 times as broad as the basal breadth of the tergite which is slightly greater than the apical breadth of the 1st tergite, the apex apparently evenly rounded; 3rd tergite with only scattered minute punctation, its median length in the ♀ about 2·7 times, and in the ♂ rather greater than twice, the median length of the 2nd tergite; ovipositor sheaths longer than the hind femora but shorter than the hind tarsus.

Length, ♀, 2·5 mm., ♂, 3 mm.

Apanteles syleptae, Ferr.

Apanteles syleptae, Ferrière, 1925, *in* Vayssière & Mimeur, L'Agron. colon., **90** : 261.

This species was originally described from 4 ♀♀, 4 ♂♂, from the SUDAN : the type is in Dr. Ferrière's collection, and one female and one male cotype in the British Museum.

In addition to the type series, this species is known to me also from the two following series, representatives of which are also in the British Museum :—
TANGANYIKA TERRITORY : Morogoro, 5 ♀♀, 3 ♂♂, 29.vii.1922 (*A. H. Ritchie*).
ANGLO-EGYPTIAN SUDAN : Talodi, Nuba Mountains Province, 1 ♂, 24.xii.1926 (*J. W. Cowland*), 2 ♀♀, 1 ♂, 30.ix.1929, 12.x.1929 (*F. G. S. Whitfield*).

Host. All the above series were bred from the Pyralid moth *Sylepta derogata*, F., on cotton.

Cocoons unknown.

Apanteles prosper, sp. n.

♀. Black; the fore-legs (except the coxae, trochanters and trochantines, and the base of the femora, which are black), the apex of the middle femora, extreme apex of the hind femora, the middle tibiae and tarsi, and about the basal half of the hind tibiae, red testaceous; remainder of the hind tibiae, and the hind tarsi, somewhat red-brown; all feet black; palpi and tibial spurs pale; flagellum dark red-brown; at least the basal half of the costal veins testaceous; remainder of the costal veins, together with the stigma and metacarp, light brown; the 1st abscissa of the radial vein, the transverse cubital, and the 2nd abscissa of the cubital, faintly pigmented, the remaining veins of both the fore- and hind-wings colourless; stigma with a faint cloud at base.

♂. Agrees with the above colour description of the female except as follows:—Apical half to three-fifths of the hind tibiae distinctly red-brown; costal margins of the stigma narrowly, and the metacarp, faintly pigmented; the remainder of the stigma, and all veins, hyaline and colourless save for some very faint pigmentation along the costal veins and the lower margins of the stigma.

♀♂. *Head*: face and clypeus with weak indefinite punctation; the clypeus not differentiated; facial depressions decidedly nearer to the apex of the clypeus than to the eyes; vertex more or less pruinose; the posterior ocelli rather nearer to each other than to the eyes. *Thorax*: mesonotum very broadly along the lines of the notauli strongly (degree 4) and fairly closely punctate, elsewhere distinctly more weakly (degree 3) and, in consequence, more widely punctate; disc of the scutellum punctate (degree 3 and 4) in the lateral thirds, more or less impunctate medianly; propodeon with the carinae of the areola, and the costulae, very weak, but sufficiently distinct; the areola extends from the base of the propodeon to the apex, with its basal breadth equal to its apical breadth, its margins in the basal half slightly diverging until the middle point is reached (whence the horizontal costulae are emitted), and in the apical half as slightly converging to the apex, the greatest breadth of the areola distinctly less than the median length; the propodeon basally to the costulae with setiferous sculpture, apically to the costulae, and in the areola, shining and devoid of sculpture. *Wings*: the 1st abscissa of the radial and the transverse cubital sufficiently rounded so that their point of junction is indeterminable, their combined length considerably greater than the breadth of the stigma; the pigmented portion of the 2nd abscissa of the cubital shorter than the upper portion of the basal vein, which is distinctly shorter than the apical portion of the 1st abscissa of the cubital, this latter shorter than the recurrent; stigma equal to or just shorter than the metacarp. *Legs*: hind coxae smooth, basally above with a small group of obscure punctures (degree 3), these however often entirely absent, apically above with minute widely separated punctures, and with the outer faces almost entirely devoid of even the minutest punctation; the hind tibial spurs subequal, the longer spur less than half the length of the basal joint of the hind tarsus. *Abdomen*: 1st tergite smooth with some indefinite sculpture in the apical third, its sides slightly diverging in the basal two-thirds, then slightly rounded to the more or less truncated apex whose breadth equals that of the base and is rather less than the greatest breadth, which is less than the median length (14 : 14 : 16 : 19); in the ♂ the tergite is apparently relatively rather narrower with its sides more approaching parallel; 2nd tergite with its lateral sulci so widely divergent basally as to be horizontal, then rounded, and apically parallel with each other, the median length of the tergite equal to that of the 3rd; 2nd and succeeding tergites with only the usual transverse row of minute punctures; hypopygium truncate; ovipositor sheaths apparently not much longer than the basal joint of the hind tarsus.

Length, 2 mm.

Uganda : Kampala, 15 ♀♀, 16 ♂♂, ii.1931 (*H. Hargreaves*).

Type deposited in the British Museum.

Host. This series is labelled " ex caterpillar D. 296."

Cocoons heaped indiscriminately together in a mass, white and with plenty of white silk.

Apanteles transvaalensis, Cam.

Apanteles transvaalensis, Cameron, 1911, Ann. Transv. Mus., **2** : 208.

This species was originally described from a single female from Pretoria, and the type is in the Transvaal Museum.

Host unknown.

Cocoons unknown.

Through the kindness of the Director of the Transvaal Museum I have been able to examine this unique specimen. It is in indifferent condition, but I have found it possible to include it in my key; and below I give a redescription of it, Cameron's description being far from satisfactory :—

♀. Black; the front legs (except for the coxae and for certain darkening of the trochanters), the middle tibiae and tarsi, the apical third of the middle femora, and about the basal half of the hind tibiae, red testaceous; palpi and tibial spurs pale; feet black; the apical half of the hind tibiae, and the hind tarsi, darkened; the wings hyaline, the costal veins testaceous; the stigma, which has an exceedingly faint cloud basally, and the metacarp, the radial, transverse cubital, and 2nd abscissa of the cubital veins, red-brown, the remaining veins colourless.

♀. *Head* : face and clypeus with regular, fairly close, minute (degree 1) punctation; the facial depressions distinctly nearer to apex of clypeus than to the eyes; clypeus not differentiated; frons more or less smooth; vertex minutely punctate at least laterally; occiput minutely punctate to pruinose; the posterior ocelli just nearer to each other than to the eyes. *Thorax* : mesonotum *pierced by pin and crumpled*, apparently with regular, fairly close punctation (degree 3); disc of scutellum with indefinite punctation, more definitely punctate along the lateral margins; the lower, smooth, non-excavate area on the lateral faces of the scutellum large, reaching quite halfway up towards base of scutellum; propodeon with indefinite punctation basally to the costulae, much smoother in the areola and beyond the costulae; the carinae of the areola and costulae not strong; the areola virtually pentagonal, the extreme base however open, the basal carinae widely divergent and straight, and the apical carinae almost as strongly convergent and so widely U-shaped that the apex of the areola is virtually straight, the greatest breadth of the areola thus hardly less than its median length; the costulae horizontal. *Wings* : 1st abscissa of the radial shorter than the breadth of the stigma, roundly angled with and longer than the transverse cubital, which is equal to the recurrent, this latter about 1·5 times the length of the apical portion of the 1st abscissa of the cubital and approaching twice that of the pigmented portion of the 2nd abscissa of the cubital (11 : 7·5 : 6); the upper portion of the basal vein short, distinctly shorter than the pigmented portion of the 2nd abscissa of the cubital; stigma shorter than metacarp. *Legs* : hind coxae above and on outer faces with an occasional exceedingly minute puncture, but here otherwise entirely smooth, but not polished, rather dull; the longer hind tibial spur five-twelfths, and the shorter spur one-third, the length of the basal joint of the hind tarsus. *Abdomen* : 1st tergite with punctation (sculpture), which is indefinite, only in the apical half, regularly turned over but not medianly tumescent, its lateral margins straight and parallel apparently throughout its length (save that possibly they converge slightly at apex), with its median length apparently in the neighbourhood of 1·7 times its median breadth; 2nd tergite with apparently but an occasional minute puncture and otherwise unsculptured, as are the succeeding tergites, with its lateral sulci and the 2nd suture but lightly marked, the lateral sulci diverging and more or less straight, and the apex of the tergite more or less evenly rounded, the median length of the tergite being considerably less than its basal breadth (which is equal to the median length of the 1st tergite), about two-fifths its apical breadth, and rather shorter than the median length of the 3rd tergite (10 : 14 : 14 : 26 : 12); hypopygium truncate; ovipositor sheaths not as long as the basal joint of a hind tarsus.

Length, 2·5 mm.

Apanteles aethiopicus, Wilkn.

Apanteles aethiopicus, Wilkinson, 1931, Bull. Ent. Res., **22** : 81.

This species was originally described from 76 ♀♀, 55 ♂♂, from UGANDA, from 11 ♀♀, 4 ♂♂, from the ITALIAN SOMALILAND, and from 57 ♀♀, 3 ♂♂, from SIERRA LEONE, and the type, which was selected from the series from Uganda, with numerous cotypes is in the British Museum.

Host. Of the material from the Italian Somaliland some of the specimens are labelled as parasites of the Arctiid moth, *Utetheisa pulchella*, L., and others of the Pyralid, *Antigastra catalaunalis*, Dup.

Cocoons white and indiscriminately heaped together.

Apanteles atellae, sp. n.

♀♂. Black; the front legs (except their coxae), the middle tibiae and tarsi, the middle femora apically and to a certain extent on the sides, and the basal fourth of the hind tibiae, red testaceous; legs otherwise red-brown, except the coxae which are black; palpi and tibial spurs pale; antennae dark brown; stigma and wing-veins uniformly brown; the wings evenly throughout, and distinctly, infumated.

♀♂. *Head* with minute punctation throughout, except the ocellar triangle which is entirely smooth, and certain median portions of the frons which are largely smooth; the clypeus hardly if at all differentiated from the face; the facial depressions nearer to apex of clypeus than to the eyes; the posterior ocelli considerably nearer to each other than to the eyes. *Thorax* : mesonotum smooth immediately anteriorly to the scutellar sulcus, otherwise punctate (degree 3 or 3–4), the punctures distinctly separated although commonly very close; disc of scutellum with some minute punctation along the lateral margins, otherwise nearly smooth; the carinae of the areola and costulae composed of two to three or more carinulae, giving a rugose effect; the areola oval, smooth, more or less closed at base; the costulae horizontal; propodeon basally dull with indefinite punctation which gives a rugulose effect, in the apical areas beyond the costulae more shining but still not smooth. *Wings* : 1st abscissa of the radial equal to and evenly rounded on to the straight transverse cubital, their point of junction more or less indeterminable; the apical portion of the 1st abscissa of the cubital, the pigmented portion of the 2nd abscissa of the cubital, and the upper portion of the basal vein, all about equal; the recurrent shorter than the breadth of the stigma, equal to the transverse cubital; stigma shorter than metacarp. *Legs* : hind coxae above entirely smooth and highly shining, otherwise with minute punctation; hind tibial spurs subequal, two-fifths the length of the basal joint of the hind tarsus. *Abdomen* : 1st tergite weakly turned over, medianly slightly rugulose, in the apical third and in the slightly excavate basal third more or less smooth, with the sides nearly, if not quite, straight and parallel, possibly slightly diverging, the median length approaching twice the median breadth (22 : 12), the apex truncate; 2nd and succeeding tergites entirely smooth (save for the usual minute transverse punctation); 2nd suture obsolete, the 2nd tergite, whose apical margin is however sufficiently distinct, shorter than the 3rd; hypopygium fairly large, acute but not strongly so, not membranous; ovipositor sheaths apparently shorter than the hind femora.

Length, 2·33 mm.

UGANDA: Kampala, 12 ♀♀, 3 ♂♂, 20.vi.1929 (*H. Hargreaves*).

Type deposited in the British Museum.

Host. The series is labelled as having been bred from the common African and Asiatic Nymphalid butterfly, *Atella phalantha*, Drury.

Cocoons indiscriminately heaped together, white, with a thin outer covering of pale yellow silk.

Apanteles endymion, sp. n.

♀♂. Black *; the front femora, the anterior tibiae and anterior tarsi, the middle femora at apex, and about the basal half of the hind tibiae, red testaceous; the hind tibiae otherwise and the hind tarsi darkened, the middle femora otherwise more strongly darkened; the hind femora dark red-brown; scape red to dark red (but not red testaceous), the flagellum red-brown; palpi and tibial spurs pale; wings hyaline; stigma and metacarp uniformly light red-brown, the former however possibly with an extremely weak trace of a cloud at extreme base; the costal veins, the radial, transverse cubital, and 2nd abscissa of the cubital, very weakly pigmented, the remaining veins colourless.

♀♂. *Head*: face punctate (degree 2) and shining, smoother laterally; the clypeus more or less differentiated and rather more coarsely sculptured; the facial depressions nearer to apex of clypeus than to eyes; the posterior ocelli rather nearer to each other than to the eyes. *Thorax*: mesonotum with fairly close, strong punctation (degree 4), the lateral sixths more weakly punctate (degree 3 or 2–3); the disc of the scutellum medianly entirely smooth, the lateral fourths punctate (degree 3); propodeon smooth and highly shining, anteriorly to the costulae however rather duller than elsewhere and with some exceedingly minute and indefinite sculpture that gives rise to weak setae; the areola, save that it is distinctly open at the base, more or less pentagonal, being truncate apically, or at least very broadly U-shaped, with the delimitating carinae virtually straight; the carinae that delimitate basally the areola commence fairly close together at the extreme base of the propodeon, whence they proceed for a short distance almost parallel to each other, quickly however strongly diverging at an angle greater than 90° to form with the costulae on each side one very strong, nearly straight, oblique carina; the carinae delimitating apically the areola strong, but often weaker than the others, converging apicad. *Wings*: the 1st abscissa of the radial and the transverse cubital straight, distinctly angled with each other, their point of junction normally slightly thickened, more usually equal to each other in length but often the radial rather longer than the transverse cubital, which is four-fifths the breadth of the stigma, equal to the recurrent, and 1·5 times as long as the apical portion of the 1st abscissa of the cubital, this latter equal to or rather longer than the pigmented portion of the 2nd abscissa of the cubital; upper portion of basal vein short; stigma and metacarp of equal length. *Legs*: hind coxae above, both basally and apically, punctate (degree 2–3), these punctures however irregular and sometimes almost absent; on outer faces in at least basal half virtually entirely smooth; the longer hind tibial spur half, and the shorter spur two-fifths, the length of the basal joint of the hind tarsus. *Abdomen*: 1st tergite shining, smooth to minutely and very indefinitely sculptured, and with some, indefinite, punctation in the apical fourth, very decidedly turned over and down but medianly not tumescent, in the basal half of the tergite the lateral margins slightly divergent, in the apical half suddenly more strongly diverging and apically as strongly converging, so that, the apical angles being not rounded, the apical breadth of the tergite is equal to its breadth at the base of the apical half, is less than its breadth at the middle of the apical half, and is greater than the breadth of its extreme base (18 : 18 : 20 : 16), the median length apparently about 1·4 times the apical breadth (25 : 18); 2nd tergite with but an occasional minute puncture (as the succeeding tergites), its apical margin very slightly curved to nearly straight, its lateral sulci widely divergent at extreme base and then nearly parallel, with the result that the tergite has much the appearance of a rectangular parallelogram, its basal breadth twice its median length and about two-thirds its apical breadth, this latter about equal to the median length of the 1st tergite (18 : 9 : 25 : 25); 3rd tergite very distinctly longer than 2nd (13 : 9); hypopygium truncate; ovipositor sheaths barely longer than the basal joint of the hind tarsus.

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* This series is somewhat immature, with the result that the coloration is inclined to be indefinite.

Length, 2·0–2·5 mm.

UGANDA: Entebbe, 27 ♀♀, 11 ♂♂, 1.viii.1910 (*C. C. Gowdey*).

Type deposited in the British Museum.

Host unknown.

Cocoons. Only one cocoon was preserved, and this is tawny and papyraceous.

SPECIES UNKNOWN TO THE WRITER OR OTHERWISE OF DOUBTFUL POSITION.

Apanteles carbonarius, Holmg.

Microgaster carbonarius, Holmgren, 1868, Eugenies Resa, Ins., p. 433.
Urogaster carbonarius, Holmgren, Roman, 1910, Ent. Tidsk., **31** : 140.

This species was originally described from a single female from MAURITIUS, and the type is in the Royal Natural History Museum, Stockholm.

Host unknown.

Cocoons unknown.

A. carbonarius is not known to me, and I have in consequence been unable to include it in my key. Dr. Roman tells me that, as may be seen from the original description, it is a typical "*Urogaster*" with areolated propodeon.

Apanteles carinatus, Szép.

Apanteles carinatus, Szépligeti, 1913, Ann. Mus. Hung., **11** : 602.

This species was described from TANGANYIKA TERRITORY, and the location of the type is unknown to the writer.

Host unknown.

Cocoons unknown.

A. carinatus is not known to me. It may be remarked that for two other species of *Apanteles* that he described on the same page Szépligeti was careful to state the sex (admittedly in one case apparently wrongly), but for *carinatus* he neglected to do so.

Apanteles discretus, Szép.

Apanteles discretus, Szépligeti, 1914, Voy. Alluaud & Jeannel Afr. orient. angl. 1911–1912, Hym. **4** : 185.

This species was described from the female, from KENYA COLONY, and the location of the type is unknown to the writer.

Host unknown.
Cocoons unknown.
A. discretus is not known to me.

Apanteles incompletus, Szép.

Apanteles incompletus, Szépligeti, 1914, Voy. Alluaud & Jeannel Afr. orient. angl. 1911–1912, Hym. **4** : 185.

This species was described from females from both TANGANYIKA TERRITORY and KENYA COLONY, and the location of the type is unknown to the writer.

Host unknown : the specimens from Kenya were taken in forests of bamboo.
Cocoons unknown.
A. incompletus is not known to me.

Apanteles lacteipennis, Szép.

Apanteles lacteipennis, Szépligeti, 1913, Ann. Mus. Nat. Hung., **11** : 602.

This species was apparently described from the female, from TANGANYIKA TERRITORY, and the location of the type is unknown to the writer.

Host unknown.
Cocoons unknown.
A. lacteipennis is not known to me.

Apanteles latiannulatus, Cam.

Xestapanteles latiannulatus, Cameron, 1910, Z. Naturw., **81** : 448.
Apanteles latiannulatus, Cameron, Muesebeck, 1931, Proc. U.S. Nat. Mus., **79**, art. 16 : 2.

This species was originally described from apparently a single pair from MOSAMBIQUE, Tette, and the type is in the Zoological Museum, Berlin.

Host unknown.
Cocoons unknown.

Through the kindness of the Director of the Zoological Museum, Berlin, I have been able to examine these two specimens. The species is, however, virtually unrecognisable as the unique individuals that represent it are in so bad a condition.

It was Muesebeck who, having examined these specimens, sunk the genus *Xestapanteles*, stating that they were unquestionably *Apanteles* and that their antennae were 18-segmented. This I should say is undoubtedly true, but now neither specimen any longer has a complete antenna ; they were received by me in this condition.

Apanteles liopleuris, Szép.

Apanteles liopleuris, Szépligeti, 1914, Voy. Alluaud & Jeannel Afr. orient. angl. 1911–1912, Hym. **4** : 185.

This species was described from the male only, from TANGANYIKA TERRITORY, and the location of the type is unknown to the writer.

Host unknown.
Cocoons unknown.
A. liopleuris is not known to me.

Apanteles orientalis, Szép.

Apanteles orientalis, Szépligeti, 1913, Ann. Mus. Nat. Hung., **11** : 602.

This species was originally described from the male only, from TANGANYIKA TERRITORY, and the location of the type is unknown to the writer.

Host unknown.

Cocoons unknown.

A. orientalis is not known to me, and is quite unrecognisable from the description.

Apanteles rugosus, Szép.

Apanteles rugosus, Szépligeti, 1914, Voy. Alluaud & Jeannel Afr. orient. angl. 1911–1912, Hym. **4** : 184.

This species was described from the male only, from Kenya Colony, and the location of the type is unknown to the writer.

Host unknown.

Cocoons unknown.

A. rugosus is not known to me.

Species Wrongly Classified.

The following species were originally described in *Apanteles*, but they are not referable to this genus.

Microgaster basimacula, Cam.

Apanteles basimacula, Cameron, 1904, Rec. Albany Mus., **1** : 173.
Microgaster basimacula, Cameron, Wilkinson, 1929, Trans. Ent. Soc. Lond., **77** : 101.

Microgaster eurygaster, Cam.

Apanteles eurygaster, Cameron, 1911, Ann. Transv. Mus., **2** : 207.
Microgaster eurygaster, Cameron, Wilkinson, 1929, Trans. Ent. Soc. Lond., **77** : 113.

Host List.

Acraea acerata, Hew.	*A. acraeae*, sp. n.
Antigastra catalaunalis, Dup.	*A. aethiopicus*, Wilkn.
Argyroploce batrachopa, Meyr.	*A. coffea*, Wilkn.
Atella phalantha, Drury	*A. atellae*, sp. n.
Busseola fusca, Fuller	*A. sesamiae*, Cam.
Chilo sp.	*A. sesamiae*, Cam.
Cirphis loreyi, Dup.	*A. ruficrus*, Hal.
Cirphis unipuncta, Haw.	*A. belliger*, Wilkn.
Danais chrysippus, L.	*A. chrysippi*, Vier.
Diacrisia mundata, Wlk.	*A. eucosmae*, Wilkn.
Diparopsis castanea, Hmps.	*A. diparopsidis*, Lyle
Diparopsis castanea, Hmps.	*A. earterus*, Wilkn.
Earias biplaga, Wlk.	*A. diparopsidis*, Lyle
Earias insulana, Boisd.	*A. diparopsidis*, Lyle
Earias insulana, Boisd.	*A. earterus*, Wilkn.
Enarmonia see *Argyroploce*.	
Euproctis sp.	*A. africanus*, Cam.
Glyphodes sericea, Drury	*A. glyphodes*, sp. n.
Gonimbrasia tyrrea, Cram.	*A. maculitarsis*, Cam.
Mylothris chloris, F.	*A. pistrinariae*, Wilkn.
Notolophus, see *Orgyia*.	
Nudaurelia cytherea, F.	*A. maculitarsis*, Cam.
Nygmea, see *Euproctis*.	
Orgyia vetusta, Hmps.	*A. africanus*, Cam.
Osteodes turbulentata, Guen.	*A. maculitarsis*, Cam.
Papilio demodocus, L.	*A. pallidocinctus*, Gahn.

Platyedra erebodoxa, Meyr.	*A. diparopsidis*, Lyle
Sesamia calamistis, Hmpsn.	*A. ruficrus*, Hal.
Sesamia cretica, Led.	*A. ruficrus*, Hal.
Sesamia cretica, Led.	*A. sesamiae*, Cam.
Sesamia, see *Busseola*.	
Sphenarches caffer, Zell.	*A. paludicolae*, Cam.
Sylepta derogata, F.	*A. sagax*, Wilkn.
Sylepta derogata, F.	*A. syleptae*, Ferr.
Thliptoceras octoguttalis, Felder	*A. coffea*, Wilkn.
Utetheisa pulchella, L.	*A. aethiopicus*, Wilkn.

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KEY TO THE ETHIOPIAN AND INDO-AUSTRALIAN SPECIES OF *APANTELES*.

In presenting this key, the writer feels that some few explanatory remarks are called for.

There have been included in this key by far the greater majority of the species of *Apanteles* described from the zoogeographical regions known conveniently as the Ethiopian and Indo-Australian; the species omitted are either unknown to the writer or have the only material representing them in so bad a condition as to render the species unrecognisable. There are also in the key a fair number of species from the Palaearctic and Nearctic regions; while in one instance, namely the *vitripennis* sub-group, there have been included virtually every species referable, or thought by the writer to be referable, to the sub-group as it is understood by the writer. It is hoped to add to this key from time to time, by completing revisions of sub-groups, as the Palaearctic species become better known and as the Nearctic species become available, and in this connection there should be here recorded the writer's appreciation of the continued support afforded him by the authorities of the United States National Museum through their policy of exchange of cotypes and authentically named material.

Group A.

Second tergite almost invariably with a pair of well-marked, usually straight, diverging, discal sulci, otherwise unsculptured save for minute punctures; propodeon either with a median longitudinal carina or transverse basal carinae, or both, or without carinae, but never with an areola or suspicion of an areola; 1st tergite with its lateral margins either regularly converging to apex, or parallel-sided and converging only at apex, or roundly broadened medianly and converging at apex; Marshall's Section IV . . . . 3.

Group F.

Second tergite almost invariably aciculate punctate, rugose, roughened, or otherwise sculptured, commonly as long as 3rd, and generally with curved sulci round the extreme lateral margins; propodeon commonly with either a median longitudinal carina, or transverse basal carinae, or with both, never with an areola or suspicion of an areola; 1st tergite at apex as broad as or broader than at base, if as broad then with the lateral margins more or less parallel throughout; ovipositor sheaths invariably short; Marshall's Sections I and III . . . . 61.

Group U.

Second tergite strongly transverse and much shorter than 3rd, with oblique sulci delimitating lateral margins, often however not strongly transverse but with lightly impressed diverging discal sulci much as in Group A, but then the tergite still relatively very much shorter than 3rd tergite; propodeon with areola which is as a rule strongly, but often obscurely, marked, but sometimes with areola entirely wanting, in which latter case there may or may not be a median longitudinal carina; costulae never present; probably all species of Marshall's Section II not possessing costulae . . . . 93.

Group S.

Second tergite much as in Group U; propodeon with areola invariably present and usually complete, at least very definitely present apically; costulae invariably present . . . . 125.

Group M.

Species not referable to any of the above groups from possessing either some part abnormally shaped or an unusual combination of those characters utilised in differentiating the above groups . . . . . 1.

The key as here published is in many respects very similar to the old key, namely that published with the writer's revision of the Indo-Australian species of *Apanteles* (1928, *Bull. Ent. Res.*, **19** : 79). This is particularly noticeable in Groups F and U, since to these two groups, as it will be observed, are referable very few described Ethiopian species. The tables for these two groups will be revised and improved as the writer's work on the Palaearctic species progresses and as more Nearctic species become represented in the British Museum, it being a curious fact that a very large proportion of the described Palaearctic species belong to these two groups.

The species have been separated out into five groups, which, since Marshall has already utilised numerals, have been named deliberately with five, arbitrary, letters, M, A, F, U, and S. These groups follow Marshall's sections very closely, and in fact are but an extension of his system. They are, with the exception of course of Group M, extremely easy to recognise, save occasionally, but extremely difficult to describe; Marshall himself even, with his restricted number of species, found this to be so. The writer believes, however, that he has made himself intelligible, if only through including in his definitions references to Marshall's well-known sections.

Group M.

1. First tergite with length more than three times median breadth, broader in apical half than medianly, broader at base than in apical half, narrowed somewhat at apex; 2nd tergite with a large discal (subtriangular) area rugose save for a narrow median longitudinal area; propodeon with weakly marked median longitudinal and transverse basal carinae . . . . 2.
   Tergites not so describable; propodeon with strongly marked median longitudinal and transverse basal carinae cutting each other to form a cross (S. Africa) . . . . *insolens*, Wilkn.
2. Apical tergites red testaceous; 1st abscissa of radial and transverse cubital without indication of even pigmentation of a stump of a 2nd radial abscissa (S. Nigeria) . . . . *pistrinariae*, Wilkn.
   All tergites black; 1st abscissa of radial almost invariably with a stump or streak of pigment at point of junction with transverse cubital (Nyasaland) . . . . *pistrinariae nyasaensis*, Wilkn.

Group A.

3. First tergite clear red testaceous throughout, without any traces of darkening 4.
   First tergite at least with some portions nigrescent or black . . . . 8.
4. Second tergite with its discal sulci evenly and only lightly impressed, and definitely reaching to 2nd suture . . . . 5.
   Second tergite with its discal sulci deeply impressed and present only in about basal half, and not reaching to 2nd suture . . . . . . 6.
5. Mesonotum pruinose; propodeon smooth; hind coxae red testaceous; 1st tergite from about base strongly and regularly constricted to apex (England) . . . . *lautellus*, Mshl.
   Mesonotum with minute punctation; propodeon smooth; hind coxae darkened to nigrescent; 1st tergite with sides parallel in at least basal three-fourths, then roundly constricted to apex (Uganda) *laxatus*, Wilkn.
   Mesonotum with definite, strong punctation; propodeon commonly with transverse basal rugosity that often appears much like transverse basal carinae; hind coxae red testaceous; 1st tergite in at least apical third strongly and regularly constricted to apex (Br. Guiana) . *guyanensis*, Cam.
6. Second tergite with its sulci widely divergent (India; Java) *papilionis*, Vier.
   Second tergite with its sulci not widely divergent . . . . 7.
7. Second tergite darkened; hypopygium large, acute; ovipositor sheaths elongate, narrow (Uganda) . . . . *gratiosus*, Wilkn.
   Second tergite not darkened; hypopygium not so describable, almost truncate; ovipositor sheaths short and broad (Kenya; Uganda) *pallidocinctus*, Gahn.
8. Propodeon with either a median longitudinal carina, or transverse basal carinae, or with both, these carinae sometimes weakly marked . . . 9.
   Propodeon without even traces either of a median longitudinal carina or of transverse basal carinae . . . . 11.

9. Propodeon with transverse basal carinae (Java) . . . . *sundanus*, Wilkn.

Propodeon without transverse basal carinae . . . . 10.

10. First tergite strongly and regularly constricted to apex; 2nd tergite striate (S. Africa) . . . . *fuscinervis*, Cam.

First tergite not so describable; 2nd tergite entirely smooth save for its sulci (Nigeria; Uganda; Belgian Congo) . . . . . *eucosmae*, Wilkn.

11. Hind femora shining red, or red-yellow, testaceous (except sometimes at apex) . . . . 12.

Hind femora black, nigrescent, or dark brown . . . . 55.

12. Hind coxae, red, or red-yellow, testaceous . . . . 13.

Hind coxae black or very strongly darkened . . . . 17.

13. Propodeon with numerous fine striae and carinulae particularly in apical half . . . . 14.

Propodeon neither striate nor carinulate . . . . 16.

14. Transverse cubital definitely and strongly angled with 1st abscissa of radial; 1st tergite wholly black (Assam) . . . . . *badgleyi*, Wilkn.

Transverse cubital not definitely and strongly angled with 1st abscissa of radial; 1st tergite not wholly black . . . . 15.

15. Hypopygium large, strongly acute; 1st tergite punctate apically (India; Malaya) . . . . *creatonoti*, Vier.

Hypopygium not so describable, smaller and approaching truncate; 1st tergite smooth throughout (U.S.A.) . . . . *militaris*, Walsh

16. First tergite sculptured at apex; 2nd tergite with a median longitudinal raised area, and with the apex emarginate (Mauritius) . *belliger*, Wilkn.

First tergite smooth at apex except at sides; 2nd tergite smooth, with its apex straight or nearly so (Ceylon) . . . . . *aristolochiae*, Wilkn.

17. Tegulae darkened to black . . . . 18.

Tegulae testaceous or red testaceous . . . . 24.

18. Propodeon with a median, longitudinal, broad, shallow excavation that is particularly noticeable towards base (Manila) . . . . *ashmeadi*, Wilkn.

Propodeon without such excavation, evenly rounded . . . . 19.

19. Second tergite shaped in an unusual manner, the apex more or less arcuately emarginate, a small elongate convex area medianly, and the discal sulci extending to apex in a curved sweep . . . . 20.

Second tergite not so describable, the discal sulci and the apex straight . 21.

20. Scape virtually entirely red testaceous; 1st abscissa of radial equal in length to breadth of stigma, rounded with transverse cubital; pupae in a large flocculent mass (Ceylon) . . . . *acherontiae*, Cam.

Scape black in apical half; 1st abscissa of radial shorter than breadth of stigma, angled with transverse cubital; pupae in a small, compact mass covered with almost parchment-like silk (India) . . . . *fabiae*, Wilkn.

21. Scape for the greater part red testaceous . . . . 22.

Scape strongly darkened to black . . . . 23.

22. Upper portion of basal vein unusually long, often as long as recurrent and always as long as apical portion of 1st abscissa of cubital; point of junction of transverse cubital with 1st abscissa of radial normally indeterminable (Java) . . . . *bataviensis*, Rohw.

Upper portion of basal vein not so describable; transverse cubital longer than, and strongly but roundly angled with, 1st abscissa of radial (Uganda) . . . . *gowdeyi*, Gahn.

23. First abscissa of radial decidedly both longer than and angled with transverse cubital; hind femora with extreme apices black (England) *caberae*, Mshl.

First abscissa of radial and transverse cubital more or less evenly rounded, their point of junction more or less indeterminable; hind femora not darkened at apex (India) . . . . *colemani*, Vier.

24. Second tergite with the discal sulci very widely divergent, very weak, and definitely not reaching apex of tergite, apex of tergite arcuately emarginate (Uganda) . . . . *ugandaensis*, Gahn.
Second tergite with the discal sulci well marked and usually reaching apex of tergite, which is not emarginate but straight (but cp. *sarrothripae*) . 25.

vitripennis SUB-GROUP.

25. Lower posterior angle of hypopygium, when viewed from side, acute or truncate, that is to say the angle formed by the posterior margin with the lower margin never greater than a right-angle . . . . 26.
Lower posterior angle of hypopygium not so describable, either rounded and ill-defined, or sharply cut away to form a short lower- (in apposition to an upper-) posterior margin that is very definitely obtusely angled with the true lower margin . . . . 46.
26. First abscissa of radial and transverse cubital without definite angulation, commonly with their point of junction indeterminable . . . . . 27.
First abscissa of radial and transverse cubital very definitely angled, more commonly very strongly so . . . . 33.
27. Propodeon dull, with usually much fine striation and some punctures, occasionally almost rugose . . . . 28.
Propodeon shining, smooth, at most with some sparse minute punctation, and/or with carination only indicating position of apex of areola . . 30.
28. Angle between the diverging discal sulci of 2nd tergite definitely equal to or greater than a right-angle (U.S.A.) . . . . *floridanus*, Mues.
Angle between the diverging discal sulci of 2nd tergite considerably less than a right-angle . . . . 29.
29. Entire apical half of 1st tergite strongly striate; apical half of mesonotum with only minute punctation (U.S.A.) . . . . . . *compressus*, Mues.
Apical half of 1st tergite with only some indefinite punctation; mesonotum with well-marked (degree 3–4) punctation (India) . . *obliquae*, Wilkn.
30. Ovipositor sheaths prominent, certainly as long as basal joint of hind tarsus, and certainly at least one-fourth length of abdomen; hypopygium large . . . . 31.
Ovipositor sheaths not prominent, apparently not as long as basal joint of hind tarsus; hypopygium small . . . . 32.
31. Second tergite entirely impunctate, with its diverging sulci straight; hypopygium acute; hind coxae with outer faces entirely impunctate and naked (Malaya) . . . . *lamprosemae*, Wilkn.
Second tergite weakly sculptured, with its diverging sulci rounded so that at apex they are nearly parallel with each other; hypopygium more truncate than acute; hind coxae on outer faces with evenly spaced minute punctures and setae (Malaya) . . . . *lamborni*, Wilkn.
32. Mesonotum with well-marked, if shallow, punctures (degree 3); 1st tergite weakly punctate along sides; angle between the diverging discal sulci of 2nd tergite approaching a right-angle (U.S.A.) *websteri*, Mues.
Mesonotum pruinose; 1st tergite distinctly striate along sides; angle between the diverging discal sulci of 2nd tergite not more than 45° (England) . . . . *lucifugus*, Lyle
33. Hind coxae basally above, and in the greater part of upper half of outer faces, highly polished and entirely smooth not even excepting the usual minute setae . . . . 34.
Hind coxae without any impunctate areas either basally above or on outer faces . . . . 38.
34. Mesonotum pruinose (West Indies) . . . . *herbertii*, Ashm.
Mesonotum not so describable . . . . 35.

35. Propodeon entirely smooth save for one or two well-marked punctures . 36.
  Propodeon not so describable, with much fine sculpture . . . . . . 37.

36. Mesonotum with minute, evenly spaced punctation throughout; 1st abscissa of radial distinctly longer than transverse cubital (Uganda) *acraeae*, Wilkn.
  Mesonotum in posterior half entirely smooth not even excepting the usual minute setae; 1st abscissa of radial distinctly shorter than transverse cubital (U.S.A.) . . . . *politus*, Riley

37. Mesonotum minutely punctate and apparently somewhat pruinose; hypopygium truncate, or nearly so (U.S.A.) . . . . *nigricornis*, Mues.
  Mesonotum strongly punctate (at least degree 3), not pruinose; hypopygium distinctly acute (India) . . . . *obliquae*, Wilkn.

38. Mesonotum with strong, evenly spaced, fairly close punctation (degree 3 or 3–4) throughout (England) . . . . *parallelus*, Lyle
  Mesonotum not so describable, pruinose or with only exceedingly minute (degree 1) punctation . . . . 39.

39. Mesonotum pruinose (England). . . . . *umbellatarum*, Hal.
  Mesonotum with exceedingly minute punctation . . . . 40.

40. Hind coxae basally above, and above generally, with much fairly strong (quite degree 3) and close punctation and striation, to weakly rugose (Europe) . . . . *lateralis*, Hal.
  Hind coxae with only minute punctation (but cp. *maculitarsis*) . . . 41.

41. Hind coxae relatively small, not as long as combined length of 1st and 2nd tergites; anterior coxae darkened (U.S.A.) . . *compressiventris*, Mues.
  Hind coxae large, as long as or longer than combined lengths of 1st and 2nd tergites; anterior coxae as clear red testaceous as femora . . . . 42.

42. Scape as clear red testaceous as femora; discal sulci of 2nd tergite diverging at an angle hardly less than 90° (India) . . . *puera*, Wilkn.
  Scape darkened; discal sulci of 2nd tergite not so widely divergent . . 43.

43. Ovipositor sheaths long, weak, narrow, more or less of same breadth throughout (Java) . . . . *belippae*, Rohw.
  Ovipositor sheaths short, strong, broad at base and thence tapering to apex . . . . 44.

44. Hypopygium distinctly somewhat acute (Europe and U.S.A.) *porthetriae*, Mues.
  Hypopygium distinctly truncate . . . . 45.

45. Propodeon punctate (degree 2–3); upper, excavate area on lateral faces of scutellum (as apposed to the lower, non-excavate area) with longitudinal crenuliform carination almost throughout (S. Africa) . *maculitarsis*, Cam.
  Propodeon with only some minute punctation (degree 1); upper, excavate area on lateral faces of scutellum almost entirely devoid of crenulation and this, when occurring, only in extreme apical angle (Europe) * *liparidis* (Bouché), Mues., and Lyle

46. Hind coxae basally above with strong (degree 4 or at least 3–4), distinct, separated punctation . . . . 47.
  Hind coxae basally above with minute punctation (degree 1 or 1–2), or if the punctation is stronger then extremely indefinite and/or certainly not describable as distinct and separated . . . . 50.

47. Discal sulci of 2nd tergite rarely cleanly marked, their presence being shown by an elongate weak depression that has numerous fine striae (but cp. *fulvipes*); their angle of divergence distinctly less than 45°, often giving the impression of being nearly parallel (U.S.A.) *sarrothripae*, Weed
  Discal sulci of 2nd tergite not so describable, cleanly marked, and with their angle of divergence distinctly greater than 45° . . . . 48.

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* *A. liparidis* (Bouché), Mues. = (*japonicus*, Ashm.), and (*posticae*, Sonan.); **synn. n.**

48. Flagellum of female of normal length, considerably longer than combined length of head and thorax . . . . 49.
Flagellum of female short and stout, about as long as combined length of head and thorax (France). . . . . *thompsoni*, Lyle
49. First tergite in at least apical half strongly contracted to apex; 2nd tergite with much fine longitudinal striation; transverse cubital equal to or longer than 1st abscissa of radial (England) . . . . . *fulvipes*, Hal.
First tergite strongly contracted only at extreme apex; 2nd tergite without much fine longitudinal striation; transverse cubital shorter than 1st abscissa of radial (Uganda) . . . . *glyphodes*, Wilkn.
50. Second tergite short and with its discal sulci very widely divergent (virtually 90°); scape as clear red testaceous as femora (India) *aristolochiae*, Wilkn.
Second tergite with discal sulci not so describable; scape usually dark or black . . . . 51.
51. Antennae of female short, their length less than combined length of head, thorax, and abdomen (U.S.A.) . . . . *sarrothripae*, Weed
Antennae of female of normal length, which is greater than or at least equal to combined length of head, thorax, and abdomen . . . . 52.
52. Transverse cubital equal to or longer than, usually longer than, 1st abscissa of radial (England) . . . . *fulvipes*, Hal.
First abscissa of radial longer than transverse cubital . . . . 53.
53. First tergite virtually parallel-sided in basal three-fourths or four-fifths, thence contracted to apex; the noticeably decurved discal sulci of 2nd tergite very fine and very lightly impressed (Java) . . *plutellae*, Wilkn.
First tergite with its lateral margins quite straight, and strongly, regularly converging to apex; discal sulci of 2nd tergite normal . . . . . 54.
54. Wings subinfumated; mesonotum in posterior half with setae hardly describable as long and thick; cocoons not pure white (England) *pinicola*, Lyle
Wings more hyaline than subinfumated; mesonotum in posterior half with setae long and thick; cocoons pure white (Europe) * *vitripennis* (Curtis), Lyle

55. Middle femora entirely light testaceous or yellowish; hind femora reddish brown . . . . 56.
Middle femora at least nigrescent basally; hind femora deep red-brown to black . . . . 58.
56. Hind coxae red, more or less unicolorous with hind femora; middle femora yellowish (Manila) . . . . *philippinensis*, Ashm.
Hind coxae black; middle femora red testaceous . . . . 57.
57. Second tergite with its discal sulci straight (Samoan Is.; Sumatra) *phytometrae*, Wilkn.
Second tergite with its discal sulci slightly curved (Malaya) *corbetti*, Wilkn.
58. Propodeon smooth . . . . 59.
Propodeon with numerous carinae and carinulae . . . . 60.
59. Stigma light red testaceous, hardly opaque, longer than metacarp; facial depressions large, with area surrounding them impressed (India) *nigrescens*, Cam.
Stigma dark brown, opaque, shorter than metacarp; facial depressions not large, with area surrounding them level (Africa) . . *africanus*, Cam.
60. Second tergite with its discal sulci straight (Fed. Malay States; Java) *artonae*, Rohw.
Second tergite with its discal sulci slightly curved (Java) . *taylori*, Wilkn.

* *A. vitripennis* (Curtis), Lyle = (*impavidus*, Gaut.); **syn. n.**

Group F.

61. Thorax compressed dorso-ventrally, wider between tegulae than thick dorso-ventrally; head viewed from side unusually prominent below antennae . . . . 62.
Thorax not compressed dorso-ventrally; head not unusually prominent below antennae . . . . 65.

flavipes SUB-GROUP.

62. Mesonotum with only minute punctation (degree 1), except possibly round anterior margin (Africa) . . . . *sesamiae*, Cam.
Mesonotum with strong, definite, exceedingly well-separated punctation . 63.
63. Propodeon with a coarse longitudinal carina at least medianly; mesonotum red testaceous (England) . . . . *ferrugineus*, Mshl.
Propodeon without such a carina; mesonotum black . . . . 64.
64. Hind coxae red testaceous; propodeon declivous behind; face prominent (India; Malaya; Formosa; Australia) . . . . . . *flavipes*, Cam.
Hind coxae black except at apex; propodeon nearly flat; face not especially prominent (Japan) . . . . *chilocida*, Vier.

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65. Second tergite with well-marked, parallel, or converging, discal sulci enclosing a definite, more or less smooth, median area . . . . . 66.
Second tergite without such sulci . . . . 68.

mlanje SUB-GROUP.

66. Discal sulci almost if not quite parallel-sided; hind coxae black (Nyasaland; Uganda) . . . . *neavei*, Wilkn.
Discal sulci strongly converging towards apex . . . . 67.
67. Hind coxae red testaceous; wings hyaline (Nyasaland) . *mlanje*, Wilkn.
Hind coxae black; wings infumated (Uganda) . . *mlanje nigricoxis*, Wilkn.

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68. Third tergite largely rugose, rugulose, or closely rugulosely striate or carinulate at least at base . . . . 69.
Third tergite smooth and shining, at least not rugulose . . . . 71.
69. All femora (except hind femora sometimes at extreme apices) entirely clear red testaceous; mesonotum in some part strongly and closely punctate . . . . 70.
Femora always very largely darkened, sometimes all completely black; mesonotum in no part strongly and closely punctate (Scotland) *salebrosus*, Mshl.
70. Four anterior coxae reddish to brownish testaceous; hind coxae on outer faces largely rugulosely striate or carinulate, and dull; propodeon medianly excavate (Portuguese E. Africa; Transvaal) . *chrysippi*, Vier.
Four anterior coxae black; hind coxae on outer faces shining, not rugulose; propodeon not excavate, with median longitudinal carina (India) *ruidus*, Wilkn.
71. Hind coxae closely rugose and dull (Cosmopolitan) . . . . *ruficrus*, Hal.
Hind coxae shining, at most closely punctate . . . . 72.
72. Transverse cubital obviously longer and stouter than 1st abscissa of radial, with a stump at their point of junction (Australia) *philoeampus*, Cam.
These veins not thus describable . . . . 73.

73. Head almost entirely with very strong, well-separated punctures (Ceylon) *pratapae*, Ashm.

Punctures on head not so describable . . . . 74.

74. Hind coxae in the greater part red testaceous . . . . 75.

Hind coxae black or strongly darkened . . . . 78.

75. Mesonotum, at least in posterior half, with only minute punctation (degree 1 or at most 2) (China) . . . . *chinensis*, Wilkn.

Mesonotum strongly punctate (at least degree 2–3) . . . . 76.

76. Scape in the greater part red testaceous; scutellar sulcus with at least eight carinae . . . . 77.

Scape dark red to nigrescent; scutellar sulcus with at most five carinae (Uganda) . . . . *flagellator*, Wilkn.

77. Posterior ocelli nearer to eyes than to each other; scutellar sulcus slightly but definitely curved; propodeon normally with strongly marked transverse basal carinae (Australia) . . . . *rufiventris*, Bingh.

Posterior ocelli not nearer to eyes than to each other; scutellar sulcus straight; propodeon with transverse basal carinae normally very weakly marked (West Indies; Florida; Texas; Western Mexico) *americanus*, Lep.

78. Mesonotum without coarse or strong punctures, if at all punctate then the punctures very shallow and virtually coalescent . . . . 79.

Mesonotum at least in some part strongly, or coarsely, and separately punctate . . . . 80.

79. Propodeon with only a weak median longitudinal carina, and no transverse basal carinae; 2nd tergite with lateral sulci definitely more strongly impressed at base than at apex . . . . *glomeratus*, L.

Propodeon with a strong median longitudinal carina, and strong transverse basal carinae; 2nd tergite with lateral sulci evenly impressed to apex of tergite (Ceylon; Sudan) . . . . *paludicolae*, Cam.

80. Propodeon with distinct transverse carinae . . . . 83.

Propodeon without such carinae . . . . 81.

81. Hind femora darkened; transverse cubital longer than 1st abscissa of radial (Australia) . . . . *radiantis*, Wilkn.

Hind femora in the greater part red testaceous; 1st abscissa of radial longer than transverse cubital . . . . 82.

82. Scape dark red-black to black; extreme apices of hind femora and of hind tibiae definitely nigrescent (Australia) . . . . . . *australiensis*, Ashm.

Scape pale red testaceous; apices of hind femora and of hind tibiae apparently not nigrescent or but hardly so (Australia) . *deliadis*, Bingh.

83. Second tergite without lateral sulci . . . . 84.

Second tergite with lateral sulci . . . . 85.

84. Hind femora red testaceous; 1st abscissa of radial longer than transverse cubital; tegulae darkened; scape red testaceous; 2nd suture strong (India; Ceylon; Java; Formosa) . . . . *taprobanae*, Cam.

Hind femora red testaceous; 1st abscissa of radial equal to transverse cubital; tegulae red testaceous; scape red testaceous; 2nd suture strong (India) . . . . *malevolus*, Wilkn.

Hind femora darkened; 1st abscissa of radial shorter than transverse cubital; tegulae red testaceous; scape darkened; 2nd suture fine (Australia) . . . . *radiantis*, Wilkn.

85. At least apical third or fourth of hind femora very strongly darkened to black . . . . 86.

Hind femora if darkened at all only at extreme apex . . . . 87.

86. First tergite with median length about equal to greatest breadth, considerably broadened at apex; scape black; 1st abscissa of radial longer than transverse cubital (England) . . . . *rubecula*, Mshl.

First tergite with median length very definitely greater than apical breadth, parallel-sided; scape dark; 1st abscissa of radial longer than transverse cubital (Tahiti) . . . . *cheesmanae*, Wilkn.
First tergite with median length greater than apical breadth, not parallel-sided; scape red testaceous; transverse cubital equal to or greater than 1st abscissa of radial (India) . . . . *jujubae*, Wilkn.
87. Tegulae darkish red to red-black . . . . 88.
Tegulae pale, colourless, or light yellowish testaceous . . . . 92.
88. First abscissa of radial equal to or even sometimes shorter than transverse cubital . . . . 89.
First abscissa of radial very definitely longer than transverse cubital . 90.
89. Second tergite indefinitely sculptured; 2nd suture as strong as the strong lateral sulci of 2nd tergite (Australia) . . . . *anthelae*, Wilkn.
Second tergite longitudinally striate; 2nd suture and lateral sulci not strong (England) . . . . *limbatus*, Mshl.
90. First tergite with lateral margins distinctly rounded to apex, which is consequently contracted (Malaya; Sumatra) . . . . *erionotae*, Wilkn.
First tergite with lateral margins not so describable . . . . 91.
91. Metacarp longer than stigma; apical portion of 1st abscissa of cubital about equal to pigmented portion of 2nd abscissa of cubital; 3rd tergite yellowish (Ceylon) . . . . *tiracholae*, Ashm.
Metacarp not longer than stigma; apical portion of 1st abscissa of cubital longer than pigmented portion of 2nd abscissa; 3rd tergite deep black (India) . . . . *effrenus*, Wilkn.
92. Lateral sulci of 2nd tergite weak; hind ocelli noticeably further from each other than from eyes (Australia) . . . . *rufiventris*, Bingh.
Lateral sulci of 2nd tergite strong; hind ocelli not so describable (India) *hypsipylae*, Wilkn.

Group U.

93. Propodeon with a strong median longitudinal carina 94
Propodeon without median longitudinal carina, with areola or strong indications of areola . . . . 101.
94. Flagellum of female with a pale band (West Indies) . *annulicornis*, Ashm.
Flagellum of female coloured normally . . . . 95.
95. Hind femora red testaceous, at most with a little darkening at extreme apex . . . . 96.
Hind femora black . . . . 98.
96. Propodeon coarsely rugose; transverse cubital considerably longer than 1st abscissa of radial (Grenada; St. Vincent) . . . * *aciculatus*, Ashm.
Propodeon not so describable; transverse cubital at most equal to 1st abscissa of radial . . . . 97.
97. Female with mesonotum and disc of scutellum red testaceous; propodeon smooth, save for its carina (Br. Guiana) . . . . . *ruficollis*, Cam.
Female with mesonotum and disc of scutellum black; propodeon with minute aciculation and carinulae in addition to its median carina (U.S.A.) . . . . *papaipemae*, Mues.
98. Hind coxae rugose (Ceylon) . . . . *recusans*, Walk.
Hind coxae not rugose . . . . 99.
99. Ovipositor sheaths very considerably longer than hind tarsus (India) *cajani*, Wilkn.
Ovipositor sheaths definitely shorter than hind tarsus . . . . 100.
100. Stigma hyaline discally, bordered with red testaceous (India) *detrectans*, Wilkn.
Stigma opaque brown (U.S.A.) . . . . *etiellae*, Vier.

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* *A. aciculatus*, Ashm. = (*thoracicus*, Mues.); **syn. n.**

101. Thorax compressed dorso-ventrally, wider between tegulae than thick dorso-ventrally; mesonotum, scutellum, metathorax, and at least anterior half of propodeon, on the same plane . . . . 102.

Thorax not so describable . . . . 103.

102. Hind legs black; metacarp if anything rather shorter than stigma (West Indies) . . . . *diatraeae*, Mues.

Hind legs largely red testaceous; metacarp distinctly longer than stigma (India) . . . . * *calycinae*, Wilkn.

103. Hind femora entirely clear red testaceous throughout . . . . . . 104.

Hind femora black, dark red, or at least black above and below . . . 108.

104. Female with 1st tergite at apex as broad as or broader than at base . . 105.

Female with 1st tergite definitely narrower at apex than at base . . . 106.

105. Mesonotum with strong, well-separated punctures (degree 4–5); propodeon almost entirely strongly rugoso-reticulate; 1st and 2nd tergites rugose; 2nd tergite at apex strongly curved (Tanganyika Territory) . . . . *trochanteratus*, Szép.

Mesonotum with definite, more or less separated, shallow punctation; propodeon only indefinitely punctate, largely smooth; 1st and 2nd tergites largely smooth; 2nd tergite at apex straight (Samoan Is.; Java) . . . . *hyblaeae*, Wilkn.

Mesonotum with close, minute punctation (degree 2); propodeon closely punctate (degree 3) in basal two-thirds; 1st and 2nd tergites striato-punctate; 2nd tergite at apex strongly curved (India) . . *rufulus*, Wilkn.

106. Tegulae black . . . . 107.

Tegulae testaceous (India) . . . . *grandiculus*, Wilkn.

107. Scape black; stigma red-brown (India) . . . . *calycinae*, Wilkn.

Scape in the greater part red testaceous; stigma dark brown to black (India) . . . . *mycetophilus*, Wilkn.

108. Mesonotum closely rugose or rugoso-punctate, dull, and strongly setiferous; disc of scutellum largely (at least lateral thirds) closely but shallowly punctate, also noticeably setiferous (Singapore) *singaporensis*, Szép.

Mesonotum neither closely rugose nor rugoso-punctate, and not dull, but shining and generally with the punctures separate, or if not separate then extremely shallowly punctate; disc of scutellum largely unsculptured . . . . 109.

109. Ovipositor sheaths definitely longer than hind tibia . . . . . . 110.

Ovipositor sheaths rather shorter than hind tibia . . . . 121.

110. Areola obviously closed at base by a straight, transverse carina as strong as or stronger than its lateral carinae . . . . 111.

Areola even if present not thus closed . . . . 113.

111. The smooth shining area on lateral faces of scutellum very small, hardly as long as breadth of scutellum at apex; disc of scutellum not entirely smooth; 1st tergite more or less longitudinally striate (India) *phycodis*, Vier.

The smooth shining area obviously much longer than breadth of scutellum at apex; disc of scutellum virtually entirely smooth; 1st tergite rugose . . . . 112.

112. Ovipositor sheaths shorter than hind tarsus (Ceylon) . . . *leptoura*, Cam.

Ovipositor sheaths longer than hind tarsus (Java) . . . *araeceri*, Wilkn.

113. Propodeon in apical half with well-marked areola, in basal half with a single well-marked, median, longitudinal carina (Java) . *araeceri*, Wilkn.

Propodeon not thus describable . . . . 114.

114. Stigma of female hyaline, margined with brown or with red testaceous . 115.

Stigma of female opaque . . . . 118.

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* Possibly not really referable here, this species is included elsewhere in the key.

115. Areola well marked throughout length of propodeon . . . . 116.

Areola marked only at apex of propodeon . . . . 117.

116. Female :—1st tergite rugose in apical half, medianly strongly tumescent; 2nd tergite smooth, with lateral sulci slightly curved; hind tibiae darkened in apical two-fifths. Male :—1st tergite in apical half rugose, medianly tumescent, with sides evenly tapering to apex; four posterior tibiae red testaceous at base, at most with hind tibiae red testaceous in basal fourth (India) . . . . *tachardiae*, Cam.

Female :—1st tergite rugose in apical half, medianly strongly tumescent; 2nd tergite finely aciculated, with lateral sulci straight; hind tibiae black in apical two-fifths. Male :—1st tergite in apical half rugose, medianly tumescent, with sides more or less evenly tapering to apex; 2nd tergite with lateral sulci straight, divergent; hind tibiae red testaceous at least in basal fourth, and middle tibiae at least in basal third (India) . . . . *machaeralis*, Wilkn.

Female :—1st tergite not rugose, and medianly not strongly tumescent; 2nd tergite smooth, with lateral sulci apparently slightly curved; hind tibiae black in apical three-fifths or two-thirds. Male :—1st tergite not rugose, with sides at apex sharply constricted; 2nd tergite with lateral sulci widely divergent and slightly curved; four posterior tibiae red testaceous only at extreme base, at the most in basal fourth (India) . . . . *importunus*, Wilkn.

117. Propodeon medianly roundly excavated; 1st abscissa of radial longer than transverse cubital (India) . . . . *leptothecus*, Cam.

Propodeon medianly strongly convex; 1st abscissa of radial not longer than transverse cubital (Europe) . . . . *halidaii*, Mshl.

118. Female with 1st tergite definitely and strongly narrowed at apex . . 119.

Female with apex of 1st tergite as broad as or broader than the base, at least not definitely strongly narrowed . . . . 120.

119. Tegulae testaceous; areola definitely reaching base of propodeon; propodeon deeply excavate medianly at base (Tanganyika; Uganda) *sagax*, Wilkn.

Tegulae dark; areola only in apical half of propodeon; propodeon not excavate basally (India) . . . . *calycinae*, Wilkn.

120. Female with 1st tergite strongly rugoso-punctate (or punctato-reticulate) (Tasmania) . . . . *tasmanica*, Cam.

Female with 1st tergite smooth, polished, and shining, with widely separated, strong punctures (Australia) . . . . *biróì*, Szép.

Female with 1st tergite finely punctate (Europe) . . . *sicarius*, Mshl.

121. Areola marked only at apex . . . . 122.

Areola strongly marked, at least in apical half . . . . 123.

122. Stigma hyaline bordered with red testaceous (India) . . *leptothecus*, Cam.

Stigma black (Europe) . . . . *sicarius*, Mshl.

123. Ovipositor sheaths only as long as basal joint of hind tarsus (Java) *javensis*, Rohw.

Ovipositor sheaths nearly as long as hind tibia . . . . 124.

124. Hind ocelli nearer to each other than to eyes (Ceylon) . *bisulcata*, Cam.

Hind ocelli nearer to eyes than to each other (India) . *machaeralis*, Wilkn.

Group S.

125. Disc of scutellum strongly rugoso-punctate, as strongly as mesonotum (Ceylon) . . . . *significans*, Walk.

Disc of scutellum not rugoso-punctate, at least not so strongly as mesonotum . . . . 126.

126. Flagellum of female with a pale band (Java) . . . *taeniaticornis*, Wilkn.

Flagellum of female coloured normally . . . . 127.

127. Female with hind femora entirely clear red, or red-yellow, testaceous, never in any part darker than basal portion of hind tibiae . . . . 128.

Female with hind femora red-brown, brown, or nigrescent, or in part or wholly black, at least in part always darker than basal portion of hind tibiae . . . . 160.

128. Female with hind coxae red or red-yellow testaceous . . . . 129.

Female with hind coxae black . . . . 135.

129. Second tergite of female more or less rectangular, with median length equal to or barely less than that of 3rd tergite . . . . . . 130.

Second tergite of female not rectangular, its lateral sulci distinct and oblique, with median length shorter than that of 3rd tergite, usually considerably so . . . . 131.

130. Hind coxae dull, closely and minutely setiferous throughout; 2nd suture fine, straight (S. India) . . . . *schoenobii*, Wilkn.

Hind coxae shining, with large areas on outer faces entirely smooth; 2nd suture broad, deep, weakly crenulate, slightly curved (concavity basad) (S. Africa) . . . . *hylas*, Wilkn.

131. First tergite with median length about equal to apical breadth (West Indies) . . . . *nigriceps*, Ashm.

First tergite with median length considerably greater than apical breadth, at least 1·5 times and usually twice . . . . 132.

132. Mesonotum nowhere with its punctation other than minute (degree 1) (Philippine Is.) . . . . *bakeri*, Wilkn.

Mesonotum with strong punctation at least anteriorly . . . . . 133.

133. Second tergite aciculated throughout (S. Africa) . . . . . *eros*, Wilkn.

Second tergite smooth . . . . 134.

134. Areola at apex very broadly rounded (**U**-shaped) (West Indies) *vulgaris*, Ashm.

Areola at apex acutely **U**-shaped, or **V**-shaped (West Indies) *leucopus*, Ashm.

135. Tegulae clear testaceous, red testaceous, or red-yellow testaceous . . 136.

Tegulae dark red, red-brown, to black, generally black . . . . . 146.

136. Stigma uniformly opaque (save for sometimes a basal cloud) . . . . 137.

Stigma discally hyaline . . . . 143.

137. Face and clypeus together elongated (N. America) . . . *crassicornis*, Prov.

Face and clypeus normal . . . . 138.

138. Hind coxae above throughout minutely rugose, and immediately below which rugosity high up on the outer faces with fine oblique striation . 139.

Sculpture of hind coxae not so describable . . . . 141.

139. Upper portion of basal vein distinctly shorter than pigmented portion of 2nd abscissa of cubital; breadth of stigma equal to distance from base of radial vein to point of junction of transverse cubital with cubital vein (West Indies) . . . . *piceoventris*, Mues.

Upper portion of basal vein distinctly as long as or longer than pigmented portion of 2nd abscissa of cubital; breadth of stigma less than distance from base of radial vein to point of junction of transverse cubital with cubital vein . . . . 140.

140. (U.S.A.) . . . . *carpatus* (Say), Gahn.

(S. Africa) . . . . *fuscicornis*, Cam.

141. Propodeon almost entirely strongly rugoso-reticulate (Tanganyika) *trochanteratus*, Szép.

Propodeon not so describable, in the greater part smooth and shining . 142.

142. Ovipositor sheaths as long as a hind tarsus; stigma with a distinct cloud occupying basal fourth (Java) . . . . *vernaliter*, Wilkn.

Ovipositor sheaths clearly shorter than a hind tarsus; stigma uniformly opaque (S. Africa) . . . . *eros*, Wilkn. (darker form).

143. Second tergite finely aciculate; 2nd suture slightly curved . . . . 144.
Second tergite smooth (apart from the usual scattered minute punctation); 2nd suture straight, fine to obsolete . . . . 145.

144. Four anterior coxae red testaceous; 1st tergite narrowed in apical half (West Indies) . . . . *rhomboidalis*, Ashm.
Four anterior coxae black; 1st tergite not narrowed in apical half (West Indies) . . . . *meridionalis*, Ashm.

145. Male with face (with clypeus) elongate, the facial depressions equidistant from apex of clypeus and eye; areola strongly marked, definitely closed at base by a carina (U.S.A.; West Indies) . *disputabilis*, Ashm.
Male with face (with clypeus) transverse, the facial depressions nearer to apex of clypeus than to eye; areola not exceptionally strongly marked and not closed at base (U.S.A.) . . . . *megathymi*, Riley

146. Scape clear testaceous or red testaceous . . . . 147.
Scape dark red, red-brown, to black, generally black . . . . . . 155.

147. First tergite discally not tumescent but with a noticeable median longitudinal carina; 2nd tergite strongly rugose; 3rd tergite generally, almost invariably, rugose (Malaya) . . . . . . *hemitheae*, Wilkn.
First tergite not so describable, at most with only a faint median longitudinal carina, and then tumescent; 3rd tergite always smooth . . . . 148.

148. Second tergite with fine, but very definite, transverse striae or aciculation at middle at apex (Java) . . . . *caniae*, Wilkn.
Second tergite without such striae . . . . 149.

149. Four anterior coxae entirely as clear testaceous as femora (West Indies) *piceoventris*, Mues.
Four anterior coxae definitely darker than femora, usually entirely dark red-black to black . . . . 150.

150. Second tergite very definitely and entirely sculptured, rugose, or rugulose; 1st tergite rugose . . . . 151.
Second tergite entirely smooth, or with some weak indefinite sparse sculpturing, never entirely sculptured . . . . 152.

151. Third tergite hardly longer than 2nd; hypopygium acute but not strongly so and not produced (Fiji) . . . . *expulsus*, Turn.
Third tergite definitely longer than 2nd; hypopygium strongly acute and strongly produced (Ceylon) . . . . *heterusiae*, Wilkn.

152. Second tergite with some slight sparse sculpturing; ovipositor sheaths at least equal to hind tarsus . . . . 153.
Second tergite entirely smooth; ovipositor sheaths not longer than hind tibiae, more often not longer than hind femora . . . . 154.

153. Ovipositor sheaths about equal to hind tarsus (India; Malaya; Manila) *stantoni*, Ashm.
Ovipositor sheaths definitely longer than hind tarsus (India) *fistulae*, Wilkn.

154. Second tergite with apex slightly curved, and with its lateral sulci present (India) . . . . *prodeniae*, Vier.
Second tergite with apex straight and parallel with base, and with the lateral sulci wanting or obsolete (Malaya) . . . . *mendosae*, Wilkn.

155. Second tergite sculptured . . . . 156.
Second tergite entirely smooth save for its lateral sulci . . . . . . 157.

156. Second tergite with fine, but very definite, transverse striae or aciculation at middle at apex (Java) . . . . *caniae*, Wilkn.
Second tergite entirely with fine longitudinal rugosity (Ceylon) *heterusiae*, Wilkn.

157. Stigma uniformly opaque; ovipositor sheaths variable . . . . . . 158.
Stigma with a large distinct cloud at base; ovipositor sheaths as long as or longer than hind tarsus . . . . 159.

158. Ovipositor sheaths shorter than hind tibiae; frontal orbits punctate; hind coxae both above and on outer faces extremely sparsely and minutely punctate (India) . . . . *prodeniae*, Vier
Ovipositor sheaths longer than hind tarsi; frontal orbits striate; hind coxae above minutely and closely punctate and striate, on outer faces extremely sparsely and minutely punctate (Siam) . . *salutifer*, Wilkn.

159. First tergite finely striate, black; abdomen black (Africa) *diparopsidis*, Lyle
Female with 1st tergite smooth, red testaceous (save for extreme lateral margins); female abdomen mostly red testaceous (Uganda) *coffea*, Wilkn.

160. Tegulae clear testaceous, red testaceous, or red-yellow testaceous . . 161.
Tegulae black . . . . 172.

161. Areola definitely closed at base . . . . 162.
Areola not definitely closed at base . . . . 165.

162. Mesonotum smooth and shining, with only minute (degree 1) punctation 163.
Mesonotum not so describable, always with stronger punctation (degree 3 or more), sometimes finely rugoso-punctate . . . . 164.

163. Stigma uniformly opaque dark brown; nervellus strongly angled at or above centre, the lower portion strongly curved back towards base of wing; posterior, polished area on lateral faces of scutellum small, semicircular (Br. Guiana) . . . . *talidicida*, Wilkn.
Stigma discally hyaline; nervellus but weakly angled and that definitely below centre, the lower portion only very weakly curved backwards; posterior, polished area on lateral faces of scutellum large, triangular (West Indies; U.S.A.) . . . . *disputabilis*, Ashm.

164. First tergite of female with median length definitely less than twice apical breadth (U.S.A.) . . . . *carpatus* (Say), Gahn.
First tergite of female with median length rather greater than twice apical breadth (Tanganyika) . . . . *coxalis*, Szép.

165. Female with stigma uniformly opaque . . . . 166.
Female with stigma hyaline . . . . 168.

166. Hind tibiae testaceous or red (not darkened) in at least basal half or three-fifths . . . . 167.
Hind tibiae testaceous at most in basal fourth (Mexico) . *albinervis*, Cam

167. First tergite slightly narrowed at apex, finely rugose with a well-marked secondary punctation; stigma noticeably broad; hind femora and tibiae almost entirely red (U.S.A.) . . . . . *carpatus* (Say), Gahn.
First tergite in apical half virtually smooth, not narrowed at apex; stigma not noticeably broad; hind femora entirely darkened (West Indies) . . . . *insularis*, Mues.

168. Hind tibiae testaceous at most in basal fourth . . . . 169.
Hind tibiae testaceous or red (not darkened) in at least basal half . . 170.

169. (Mexico) . . . . *albinervis*, Cam.
(N. America). . . . . *cacoeciae*, Riley; ? = (*harti*, Vier.).

170. First tergite of female definitely narrowed in apical third (West Indies) *leucostigmus*, Ashm.
First tergite of female definitely not narrowed at apex . . . . . . 171.

171. Mesonotum minutely rugoso-punctate evenly throughout; disc of scutellum with some punctures along sides; 2nd tergite with median length distinctly longer than lateral length (U.S.A.; West Indies) *thurberiae*, Mues.
Mesonotum not evenly and regularly sculptured; disc of scutellum more or less entirely smooth; 2nd tergite with median length not distinctly longer than lateral length, more approaching rectangular (West Indies) *balthazari*, Ashm.

172. Females with stigma discally hyaline and narrowly margined with pigmentation . . . . 173.

Females with stigma uniformly opaque, or with very faint cloud at extreme base, at most with a cloud in basal fourth . . . . 176.
173. At least apical three-fourths of hind tibiae, and the greater part of the hind tarsi, strongly darkened to black . . . . 174.
At most apical half of hind tibiae, and the hind tarsi to some extent, darkened . . . . 175.
174. A median longitudinal carina in basal third of propodeon connecting the basally closed areola with base of propodeon; female with 1st tergite rugose, and 2nd minutely rugose (Europe) . . *anarsiae*, Faure & Alab.
No median longitudinal carina in basal third of propodeon, the areola open basally and not connected with base of propodeon; female with neither 1st nor 2nd tergite rugose (Sudan) . . . . *earterus*, Wilkn.
175. Mesonotum in part rugose, or rugosely striate, noticeably so along lines of notauli posteriorly (India; Java; Ceylon) . . . . *taragamae*, Vier.
Mesonotum in no part rugose or rugosely striate, in posterior half noticeably smooth and shining with the punctures noticeably well separated (Malaya) . . . . *baoris*, Wilkn.
176. Mesonotum compressed dorso-ventrally, the mesonotum, disc of scutellum, propodeon anteriorly, virtually on one plane; 1st tergite of female elongate, narrow, with median length nearly three times median breadth (16 : 6); 2nd tergite with discal sulci so that its median length is greater than its basal breadth (Uganda) . . . . . *afer*, Wilkn.
Species not so describable . . . . 177.
177. Hind coxae in at least upper half rugulose and/or striate . . . . . 178.
Hind coxae neither rugulose nor striate, usually smooth, shining, and with only minute punctation . . . . 179.
178. Median length of 3rd tergite about 2·7 times as long as that of 2nd tergite (Tanganyika) . . . . *langerburgensis*, Szép.
Median length of 3rd tergite not twice as long as that of 2nd tergite (Sudan; Tanganyika) . . . . *syleptae*, Ferr.
179. Males with stigma discally hyaline and narrowly margined with pigmentation . . . . 180.
Males with stigma as in female . . . . 185.
180. Areola and costulae very strong, the areola V-shaped at apex and more or less closed at base by rugose carinae (Manila) . . * *opacus*, Ashm.
Areola and costulae not so describable . . . . 181.
181. Second tergite rugose . . . . 182.
Second tergite entirely smooth . . . . 183.
182. Middle femora only in apical fourth, and hind tibiae in basal third, red testaceous, otherwise black; hind femora entirely black; stigma without even traces of basal cloud (Europe; U.S.A.) . *lacteicolor*, Vier.
Middle femora entirely, and at least basal half of hind tibiae, red testaceous; hind femora merely somewhat darkened; stigma with faint cloud at extreme base (Marquesas) . . . . * *mendañae*, Wilkn.
183. Female with median length of 3rd tergite equal to that of 2nd (Uganda) *prosper*, Wilkn.
Female with median length of 3rd tergite distinctly longer than that of 2nd 184.
184. Female with apical breadth of 1st tergite hardly greater than median length of 2nd (12 : 11) (S. Africa) . . . . . * *transvaalensis*, Cam.
Female with apical breadth of 1st tergite considerably greater than, almost twice, median length of 2nd (15 : 8) (Africa) . *aethiopicus*, Wilkn.
185. Scape testaceous . . . . 186.
Scape black, or at least not testaceous . . . . 189.
186. Ovipositor sheaths shorter than hind femora; 2nd tergite with fine but distinct rugosity (Marquesas) . . . . *mendañae*, Wilkn.

* Males not known, the species consequently included on both sides of the key.

Ovipositor sheaths as long as or longer than hind femora; 2nd tergite smooth save for some indefinite punctation . . . . 187.

187. Second suture straight (Java; Manila) . . . . *parasae*, Rohw.

Second suture of female curved . . . . 188.

188. Radial vein not distinctly angled with transverse cubital; ovipositor strong, stout (Java) . . . . *hasorae*, Wilkn.

Radial vein distinctly angled with transverse cubital; ovipositor more slender (Malaya) . . . . *inquisitor*, Wilkn.

189. Carinae of areola and costulae very strong; areola V-shaped at apex and more or less closed at base by rugose carinae; 1st tergite rugose and with a very strong median rugose tumescence; disc of scutellum with numerous strong punctures (Manila) . . . . *opacus*, Ashm.

Carinae of areola and costulae not so describable, or at least not combining the above characters . . . . 190.

190. Disc of scutellum very flat, very highly polished and shining, entirely devoid of any sort of punctation or sculpture not even excepting the usual very minute punctation of the minute setae . . . . 191.

Disc of scutellum convex, to some extent punctate, often fairly strongly so, or sculptured, and more or less dull . . . . 195.

191. Mesonotum in posterior half very highly polished and shining, with some very widely separated (usually at least two diameters), strong punctures, largely impunctate (Fiji) . . . . *platyedrae*, Wilkn.

Mesonotum not so describable . . . . 192.

192. Stigma with a distinct cloud in basal third or fourth (Africa) *diparopsidis*, Lyle

Stigma uniformly opaque . . . . 193.

193. Mesonotum with the punctation of the lines of notauli striate, particularly in posterior third; 1st tergite strongly narrowed in apical third, and with a strong median rugose tumescence (Malaya; Java) *tirathabae*, Wilkn.

Mesonotum with strong, close punctation, nowhere striate; 1st tergite not narrowed in apical third, or at least not strongly so . . . . . . 194.

194. First tergite striate almost throughout apical half, and with a finely rugose median tumescence; female with 2nd suture bisinuate, and with median length of 2nd tergite greater than half apical breadth of 1st (India) *bambusae*, Wilkn.

First tergite in apical half medianly unsculptured and shining, laterally with punctures and striae, with a weakly rugose, weak, median tumescence; female with 2nd suture evenly rounded, and with median length of 2nd tergite less than half apical breadth of 1st (Java) *hasorae*, Wilkn.

First tergite without median tumescence or rugosity, in apical half with strong punctures, and striate laterally at extreme apex; female with 2nd suture almost straight, and with median length of 2nd tergite greater than half apical breadth of 1st (Manila; Sumatra; Java) . *agilis*, Ashm.

195. Wings very distinctly infumated; median length of 1st tergite of female nearly twice median breadth (22 : 12); 2nd suture apparently wanting; ovipositor sheaths shorter than hind femora (Uganda) . . *atellae*, Wilkn.

Wings not infumated, or at least not combining the above characters . 196.

196. Stigma with very distinct cloud in basal third or fourth; ovipositor sheaths clearly as long as hind tibiae (Africa) . . . *diparopsidis*, Lyle

Stigma uniformly opaque, or virtually so . . . . 197.

197. First tergite smooth, at most with some, rather indefinite, sculpture and/or punctation, medianly not tumescent . . . . 198.

First tergite in apical half definitely striate, rugose, or rugoso-punctate, or at least with a strong median rugose tumescence . . . . 200.

198. Costulae weak, horizontal (S. Africa) . . . . . *transvaalensis*, Cam.
Costulae strong, oblique . . . . 199.

199. Ovipositor sheaths about as long as hind tibiae (Manila; Sumatra; Java) *agilis*, Ashm.
Ovipositor sheaths about as long as basal joint of hind tarsus, at least considerably shorter than hind femora (Uganda) . . *endymion*, Wilkn.

200. Ovipositor sheaths very short, the hypopygium not membranously acute (Java) . . . . *hyposidrae*, Wilkn.
Ovipositor sheaths at least as long as hind femora, the hypopygium membranously acute . . . . 201.

201. Areola V-shaped beyond costulae and closed basally by a weak carina (France) . . . . *galleriae*, Wilkn.
Areola not so describable . . . . 202.

202. Propodeon with costulae weak and more or less horizontal; 1st tergite slightly but definitely narrowed in apical third, with median tumescence only minutely rugose, in apical half more or less entirely with fine but very distinct longitudinal striae (India) . . . . . *bambusae*, Wilkn.
Propodeon with costulae strong and at least more or less oblique; 1st tergite not narrowed in apical third, with at least the median tumescence very definitely rugose . . . . 203.

203. First abscissa of radial very definitely longer than and angled with transverse cubital (Java; Manila) . . . . *parasae*, Rohw.
First abscissa of radial not definitely angled, more or less evenly rounded, with transverse cubital, and certainly not definitely longer than this latter, more or less equal to it (Java) . . . . . *hasorae*, Wilkn.

INDEX TO SPECIES INCLUDED IN THE KEY.

acherontiae, Cam.
aciculatus, Ashm.
acraeae, Wilkn.
aethiopicus, Wilkn.
afer, Wilkn.
africanus, Cam.
agilis, Ashm.
albinervis, Cam.
anarsiae, Faure & Al.
annulicornis, Ashm.
anthelae, Wilkn.
araeceri, Wilkn.
aristolochiae, Wilkn.
artonae, Rohw.
ashmeadi, Wilkn.
atellae, Wilkn.
australiensis, Ashm.
badgleyi, Wilkn.
bakeri, Wilkn.
balthazari, Ashm.
bambusae, Wilkn.
baoris, Wilkn.
bataviensis, Rohw.
belippae, Rohw.
belliger, Wilkn.
birói, Szép.
bisulcata, Cam.
caberae, Mshl.
cacoeciae, Riley
cajani, Wilkn.
calycinae, Wilkn.
caniae, Wilkn.
carpatus, Say
cheesmanae, Wilkn.
chilocida, Vier.
chinensis, Wilkn.
chrysippi, Vier.
coffea, Wilkn.
colemani, Vier.
compressiventris, Mues.
compressus, Mues.
corbetti, Wilkn.
coxalis, Szép.
crassicornis, Prov.
creatonoti, Vier.
deliadis, Bingh.
detrectans, Wilkn.
diatraeae, Mues.
diparopsidis, Lyle
disputabilis, Ashm.
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effrenus, Wilkn.
endymion, Wilkn.
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etiellae, Vier.
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halidaii, Mshl.
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hasorae, Wilkn.
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herbertii, Ashm.
heterusiae, Wilkn.
hyblaeae, Wilkn.
hylas, Wilkn.
hyposidrae, Wilkn.
hypsipylae, Wilkn.

(*impavidus*, Gaut.)
importunus, Wilkn.
inquisitor, Wilkn.
insolens, Wilkn.
insularis, Mues.
(*japonicus*, Ashm.)
javensis, Rohw.
jujubae, Wilkn.
lacteicolor, Vier.
lamborni, Wilkn.
lamprosemae, Wilkn.
langerburgensis, Szép.
lateralis, Hal.
lautellus, Mshl.
laxatus, Wilkn.
leptothecus, Cam.
leptoura, Cam.
leucopus, Ashm.
leucostigmus, Ashm.
limbatus, Mshl.
liparidis, Bouché
lucifugus, Lyle
machaeralis, Wilkn.
maculitarsis, Cam.
malevolus, Wilkn.
megathymi, Riley
mendañae, Wilkn.
mendosae, Wilkn.
meridionalis, Ashm.
militaris, Walsh
mlanje, Wilkn.
mycetophilus, Wilkn.
neavei, Wilkn.
nigrescens, Cam.
nigriceps, Ashm.
nigricornis, Mues.
obliquae, Wilkn.
opacus, Ashm.
pallidocinctus, Gahn.
paludicolae, Cam.
papaipemae, Mues.
papilionis, Vier.
parallelus, Lyle
parasae, Rohw.
philippinensis, Ashm.
philoeampus, Cam.
phycodis, Vier.
phytometrae, Wilkn.
piceoventris, Mues.
pinicola, Lyle
pistrinariae, Wilkn.
platyedrae, Wilkn.
plutellae, Wilkn.
politus, Riley
porthetriae, Mues.
(*posticae*, Sonan)
pratapae, Ashm.
prodeniae, Vier.
prosper, Wilkn.
puera, Wilkn.
radiantis, Wilkn.
recusans, Walk.
rhomboidalis, Ashm.
rubecula, Mshl.
ruficollis, Cam.
ruficrus, Hal.
rufiventris, Bingh.
rufulus, Wilkn.
ruidus, Wilkn.
sagax, Wilkn.
salebrosus, Mshl.
salutifer, Wilkn.
sarrothripae, Weed
schoenobii, Wilkn.
sesamiae, Cam.
sicarius, Mshl.
significans, Walk.
singaporensis, Szép.
stantoni, Ashm.
sundanus, Wilkn.
syleptae, Ferr.
tachardiae, Cam.
taeniaticornis, Wilkn.
talidicida, Wilkn.
taprobanae, Cam.
taragamae, Vier.
tasmanica, Cam.
taylori, Wilkn.
thompsoni, Lyle
(*thoracicus*, Mues.)
thurberiae, Mues.
tiracholae, Ashm.
tirathabae, Wilkn.
transvaalensis, Cam.
trochanteratus, Szép.
ugandaensis, Gahn.
umbellatarum, Hal.
vernaliter, Wilkn.
vitripennis, Curtis
vulgaris, Ashm.
websteri, Mues.

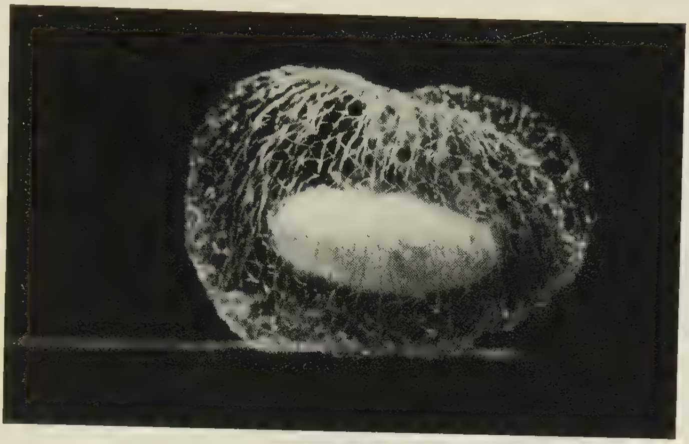

Fig. 1. Puparium of *Apanteles acraeae* **sp. n. (× 8).**

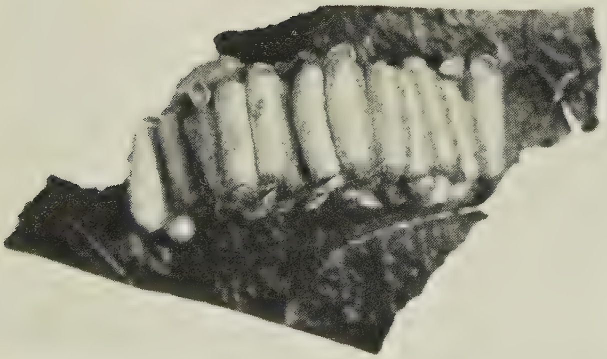

Fig. 2. *Apanteles pistrinariae*, **Wilkn.: A Typical heap of cocoons. (× 4).**

The cocoons of two African species of *Apanteles*.

INSECT COLORATION AND THE RELATIVE ACCEPTABILITY OF INSECTS TO BIRDS

By Frank Morton Jones, Sc.D.

[Read 1st June, 1932.]

With Plates XVIII to XXVIII.

The series of experiments upon which this paper is based were performed on the island of Martha's Vineyard, Massachusetts, during the summers of 1930 and 1931. In the gathering of material for experiment, the continuous aid of George D. Eustis, Esq., of Hollyholm, Martha's Vineyard, was invaluable. Insect species of special interest were furnished by Messrs. Henry Bird and George P. Engelhardt of the New York Entomological Society. Mr. C. W. Johnson of the Boston Museum of Natural History aided greatly by identification of insects. The careful work of Miss Helen Winchester, artist of the Academy of Natural Sciences, Philadelphia, contributed to the accuracy of the coloured plate.

To Professor E. B. Poulton I am especially indebted for constant encouragement, as also to the Fund for promoting the Study of Organic and Social Evolution, presented in his name by Professor James Mark Baldwin to the University of Oxford, for a generous grant toward the expense of publication.

The theory of "warning coloration" depends for its validity upon the belief that colour and colour-pattern (or qualities correlated with these characters) exercise a determining effect upon the relative acceptability, to predacious animals, of their prey; and "protective mimicry," as an explanation of the (often detailed) resemblances in colour, pattern, posture, shape, or habit, exhibited by animals not necessarily closely related, can be true only if the mimicked animals, the "models," derive some degree of immunity from attack through the possession of the characters mimicked. Evidence that colours and colour-patterns do influence relative acceptability would not alone constitute proof of these theories; but thus basic to their truth, becomes a logical starting-point for their investigation.

The experiments to be described were undertaken to determine both the relative acceptability of some insects to insectivorous birds and the basis of any discrimination which might be observed. They avoid one criticism directed against many past experiments, in that they record the uninfluenced choice of wild birds, free to come or go or to seek other food at will. The experiments are not free from artificiality, in that the insects made available to the birds were not living but were freshly killed, and that these insects were offered in assemblages which for numbers and variety within limited space are rarely duplicated in nature; but discrimination exhibited under these conditions is a reality, scarcely explicable except as consistent with the usual reactions of the birds in their selection of insect food.

In the conduct of these experiments, a feeding-tray (Pl. XIX, 1) was established at the edge of an extensive bird-frequented woodland; and upon this a daily supply of water and of food in small quantities (seeds, grains, suet) served to attract the nesting resident birds of several species, and other wide-ranging birds whose visits were casual and less regular. At intervals, instead of or in addition to other food, freshly-killed insects which had been tabulated for species and numbers were placed upon the tray. From a distance (through field-glasses) the bird visits were observed and recorded; and retabulations of the insects at frequent intervals in the progress of each experiment yielded knowledge of the approximate order of acceptance of the insects eaten by the birds, when this could not be determined by direct observation.

These experiments were continued for two seasons, from mid-June to early September, and record was thus obtained of the approximate order of acceptance (or of the eventual failure to accept) of more than five thousand insects belonging to two hundred species. Most of these insects were procured by the operation of light-traps; others which it seemed desirable to test were collected in the field; a few were bred; and many were supplied by entomological friends who sent or brought them to me, alive or freshly killed.

The number of insects spread upon the tray at any one time averaged about fifty, and rarely exceeded one hundred or fell below twenty-five. These numbers, when the periods of experiment and the numbers of visiting birds are taken into account, did not deter acceptance through repletion; and an occasional shift of the place of experiment to a distant point, where a new set of bird visitors was involved and similar results obtained, evidenced that acceptance was not dependent upon a formed habit of finding food upon the tray.

Bird visits often commenced immediately upon the display of the tabulated insects. Often an experiment was concluded within half an hour of its inception; but not rarely, two or three hours would elapse before all the more acceptable insects had been eaten, the bird visits had become infrequent or had ceased, and the experiment was terminated. Many of the insects were eaten by birds which made prolonged stays upon the tray and which made leisurely and extensive selection from its contents (Pl. XIX, 2, 4); others were snatched up and carried elsewhere—usually to the ground below—to be consumed; many (a beak-full at a time (Pl. XIX, 3)) were carried to nestling young; fledged young were brought to the tray and fed by their parents from its contents; and in the later season, young birds in the plumage of immaturity were frequent visitors. Often several feeding birds, and sometimes birds of several species, were upon the tray at once. The bird visits, by species and individuals, were recorded for each of the timed periods of insect tabulation, so that it was often possible to determine what bird species accepted or failed to accept any given insect. The number of bird species visiting the tray was not great, and most of the records are based upon the behaviour of the first eight species in the table given on p. 347, these eight being the only frequent visitors feeding freely upon the offered insects.

Early in the series of experiments it became evident that *size* had great influence upon the order of acceptance, and that some whole groups, in general, were readily accepted by these birds, while other groups (Orders) of insects were often disregarded and left upon the tray uneaten or were slowly accepted after other food had been consumed. Most moths and most beetles were readily accepted in whatever quantities provided; and for this reason, as well as for their greater availability in adequate numbers and variety, they constituted the majority of the insects used in the experiments. Continuous effort was made to ensure that in every experiment each included species of insect should be in competition with some others of like size and general character, and of proven acceptability; and that the various insect species should be thoroughly mixed in their distribution upon the tray, so that none should have avoidable advantage of position. The method of experiment and the nature of the evidence obtained may be visualised by reference to Appendix A (pp. 372 to 379), where the records of eight of these experiments are given in detail. (See also Pls. XX to XXVIII inclusive.)

Birds.	Bird Visits.
1. Towhee Fringillidae, *Pipilo erythrophthalmus* (Linn.)	578
2. Song Sparrow Fringillidae, *Melospiza melodia* (Wils.)	536
3. Blue Jay Corvidae, *Cyanocitta cristata* (Linn.)	169
4. Grackle Icteridae, *Quiscalus quiscula* (Linn.)	157
5. Robin (American) Turdidae, *Turdus migratorius* (Linn.)	263
6. Brown Thrasher Mimidae, *Toxostoma rufum* (Linn.)	34
7. Catbird Mimidae, *Dumetella carolinensis* (Linn.)	157
8. Cowbird Icteridae, *Molothrus ater* (Bodd.)	15
9. House Sparrow Ploceidae, *Passer domesticus* (Linn.)	5
10. Bob-white Perdicidae, *Colinus virginianus* (Linn.)	10
11. Chipping Sparrow Fringillidae, *Spizella passerina* (Bech.)	3
	1927*

* The total number of observed bird visits was in excess of 2000; but in some of the earlier experiments the birds were recorded by species only and not by number of visits.

The eight experiments there recorded in full are extremely definite in their implications that under the conditions of experiment some insects are readily acceptable, that others are positively unacceptable, to these birds; but not all the experiments supply such obvious evidence. Sometimes, *all* the insects were taken from the tray; and from such records the order of acceptance, as shown by successive tabulations, is the only basis for their utilisation in a study of comparative acceptability. Even if it were practicable to publish in detail the records of all the experiments (numbering more than one hundred, involving more than two thousand bird visits and the use of more than five thousand insects), it would not easily be possible, by direct comparison of these voluminous records, to make a fair appraisal of the evidence they contain regarding each of the two hundred or more insect species, some of which were used in large numbers and in many experiments, some in very limited numbers and in few experiments. An impartial method of summarising and classifying that evidence is so obviously a desideratum that I have endeavoured to derive from these records, in so far as they furnish a basis for such computation, a *numerical expression of comparative acceptability* for each of these insect species.

To this end, each experiment has been considered separately. All the insects taken by the birds in the first period before retabulation have been assigned to " acceptability 100." All those left on the tray at the termination of the experiment, to " acceptability 0." For the insects taken by the birds between each of the intermediate tabulations, the exact order of acceptance for any given insect is not often determinable from the record; but by assigning to all of the insects taken between any two consecutive tabulations an acceptability-rating based on the *numerical median* of those taken in that series, the possible variation from the actual is reduced to the minimum. Finally, by assembling the records of each insect species, by numbers of each and their calculated ratings in the several experiments, an average " acceptability rating " for that species is obtainable, which as nearly as may be expresses impartially the results of all the experiments in which that species may have been involved. Further explanation and illustration of the method by which intermediate ratings were computed will be found in Appendix B (p. 380).

It should be noted that this does not take into account any interpretation of the behaviour of the birds based upon their supposed experience or inexperience, their hunger, their age, or on manifestations of dislike or disgust. These compilations, based thus and only upon the approximate order of acceptance or of failure to accept over the period of experiment, give for the insects comparatively few acceptability ratings of 100 or of 0; for some fully acceptable insects, numerously represented in an experiment, of mathematical necessity may remain upon the tray through one or several tabulations and thus receive a lower rating; and occasionally an insect whose record is otherwise that of uniform refusal, is taken from the tray in the progress of some one experiment, and thus has its rating materially advanced. It is apparent, therefore, that an experiment which includes only a single representative of any insect, for that insect may give results which will be entirely contradicted by a series of experiments; and that such records, considered alone, have limited evidential value.

Some of the experiments were abruptly terminated by weather conditions, by the approach of darkness, or by the enforced absence of the recorder, and a few others were not sufficiently detailed in identifications and listings of the insects involved. Excluding these only, it has been found practicable to utilise ninety experiments in the computation of these ratings; and the lists which follow include all of the identified moths, butterflies, and beetles, and a few of the other insects, used in these ninety experiments. For each insect species, the information given in the lists includes the number of experiments in which it was used; the total number of insects in competition and the number of insects of the species under consideration, in those experiments; its averaged acceptability rating; and a list of the species of birds (indicated by numerals, as designated on p. 349) which visited the tray in the course of those experiments. A bird numeral in italics indicates that this bird was observed to accept the listed insect—a fact not always determinable in the progress of an experiment, hence the absence of italics does not imply non-acceptance by any of the listed bird visitors.

For reasons which will become apparent, the lists have been divided into three sections; those of insects with acceptability ratings between 60 and 100: those ranging from 25 to 60; and those which rate 25 or lower. Perusal of the detailed lists is not necessary for an understanding of the continuation of this paper, but for purposes of record and reference; they have therefore been relegated to Appendix C (pp. 381 to 385), Sections I, II, and III. These lists do not there include the butterflies, which will be given consideration later. They also omit the names of three insects not specifically identified in time for inclusion here, though mentioned elsewhere, and whose present omission in no way affects the significant results.

Some of these results will be more apparent if we consider the lists, or portions of them, in more condensed form. Section I (pp. 381 to 382), listing insects whose acceptability ratings range from 60 to 100, with the added record for each group of the numbers left upon the tray uneaten at the conclusion of the experiments involving them, may be summarised thus :—

Summary, Section I, of Insect Species Rating from 60 to 100.

Lepidoptera.	No. of species.	No. of insects.	Average acceptability.	Left on tray.	Bird visitors.
Sphingidae . .	7	95	93·3	0	*1*, 2, *3*, 4, *5*, *7*, 9, 10
Saturniidae . .	2	14	82·2	0	*1*, *2*, 3, *4*, 5, 6, 7
Arctiidae . .	7	119	69·1	2	*1*, *2*, *3*, *4*, *5*, 6, *7*, 8, 11
Noctuidae . .	38	666	78·3	3	*1*, *2*, *3*, 4, *5*, *6*, *7*, 8, 9, 10
Notodontidae .	11	311	80·4	1	*1*, *2*, *3*, 4, *5*, *6*, 7, 8, 9, 10
Lymantriidae .	1	56	84·9	0	*1*, *2*, *3*, 4, *5*, 6, 7, 8
Eupterotidae .	1	23	86	0	*1*, 2, *3*, 4, *5*, 7
Lasiocampidae .	1	146	75·3	0	*1*, *2*, *3*, *4*, *5*, *6*, *7*, 8, 9
Geometridae .	8	120	71·7	3	*1*, *2*. *3*, 4, *5*, 6, 7, 8, 9
Limacodidae .	1	5	81	0	*1*, 2, 4, 5, 7
Tortricidae . .	1	5	71·6	0	2, 4, 5, 7, 8
Total Lepidoptera	78	1560	78·5	9	*1*, *2*, *3*, *4*, *5*, *6*, *7*, 8, 9, 10, 11
Coleoptera.					
Tenebrionidae .	1	2	79	0	1, 2, 4
Scarabaeidae .	11	847	78·7	18	*1*, *2*, *3*, 4, *5*, *6*, *7*, 8, 9, 10, 11
Total Coleoptera .	12	849	78·7	18	*1*, *2*, *3*, 4, *5*, *6*, *7*, 8, 9, 10, 11
General total .	90	2409	78·6	27	*1*, *2*, *3*, *4*, *5*, *6*, *7*, 8, 9, 10, 11

This shows that among 2409 insects of the 90 species having these ratings, all but 27 were taken from the tray in the progress of the experiments in which these species were involved. Stated otherwise, 98·8% of 2409 insects of these 90 species were eaten, only 1·1% were left uneaten upon the tray. This seems conclusive that the nature and conduct of the experiments offered no bar to the full acceptance of these insects by at least seven bird species, and that the experiments were carried far enough to eliminate the more desirable species from the tray. If then other insect species or groups of species, offered in these same experiments and in competition with these insects of demonstrated acceptability, should exhibit relatively widely divergent rates of acceptance (or even in some cases an entire failure to be accepted), it would seem a safe conclusion that some deterring character or characters possessed by these latter insects must be responsible for that difference in behaviour on the part of the bird visitors to the tray.

One reason for a slowing up in the acceptance of some insects is not far to seek, and often became apparent in the conduct of a single experiment : whether consciously or not, the birds are greatly influenced in the order of their acceptance of insects, by *size.* This statement is readily confirmed by a study of the tabulated experiments. Of the Families of the Lepidoptera used in safely significant numbers in these experiments, the Sphingidae included the uniformly larger insects. Of seven species and ninety-five insects of this Family, *all* were eaten, with a family acceptability rating (Summary, Section I) of 93·3, the highest of all the families of the Order. From the same table and representative of moderately sized insects, the Noctuidae and Notodontidae, including forty-nine species, nine hundred and seventy-seven insects, show a combined average rating of 79, with only four of these insects left on the tray at the conclusion of the experiments. Illustrative of smaller insects of the same Order, the Pyralid, *Nomophila noctuella* (List, Section II) was used in twenty-eight experiments including one hundred and eighty-five insects of this species in a total competition of sixteen hundred and sixty-nine, receiving a rating of 52·2, with eight of the one hundred and eighty-five left upon the tray uneaten.

In the Coleoptera parallel conditions are apparent. The largest Scarabaeid used in the experiments, *Polyphylla variolosa* (List, Section I)—of this species, one hundred and thirty-five insects were included and all were eaten—shows the highest acceptance rate, 92·6. Slightly smaller insects of the same family, *Phyllophaga gracilis*, *fusca*, *forsteri*, *crenulata*, a total of three hundred and seven insects, show a combined average acceptability of 81·2, with five remaining uneaten. Still in the same family, similar in general appearance, but less than half the size, are *Serica georgiana*, *S. sericea*, and *Diplotaxis sordida*; of these three species three hundred and thirty-five insects were used, they received a combined rating of 58·8, and fourteen were left upon the tray uneaten. The result of thus comparing these selected groups becomes more readily apparent by tabulating them thus :—

	No. of these insects used.	Acceptability.	Left on tray.
Larger Lepidoptera . . .	95	93·3	0
Medium Lepidoptera . . .	977	79	4
Small Lepidoptera	185	52·2	8
Larger Coleoptera	135	92·6	0
Medium Coleoptera . . .	307	81·2	5
Small Coleoptera	335	58·8	14

I do not interpret this to signify that these smaller insects are not fully acceptable to the birds in their search for food; but it is obvious that in the conduct of these and of similar experiments, we must not overlook this definite response to size, as a factor of importance in the relative order of acceptance of insects by birds, when insects of various sizes are in competition for their attention.

That size, however, cannot be the sole factor, or in these experiments indeed the principal one, became apparent in their progress and is clearly deducible from their assembled records. In illustration, the three sections of the list, I, II, and III, may be condensed thus :—

Section of List.	Range of accept-ability.	No. of species.	No. of insects.	Average rating.	Left on tray.	% left on tray.
I	60–100	90	2409	78·6	27	1·1
II	25–60	71	1359	45·6	188	13·8
III *	0–25	31	423	4·2	383	90·5

* Limited to Lepidoptera, Coleoptera, Hemiptera, in line with I and II.

In comparison with those of Section I, the 423 insects of Section III show *eighty times as many*, proportionately, left upon the tray uneaten at the conclusion of the experiments in which both series of insects participated; and though it is true that the average size of the insects listed in Section III is less than the average of those included in Section I, yet insects of fairly comparable size abound in all three Sections of the List, and the extreme differences of acceptability ratings apparent in the above tabulation are not explicable on the basis of differences in size. For many of the included species this statement will receive abundant confirmation in later direct comparisons, and obviously we must look elsewhere for some important factor which will account for the discrimination made apparent by this comparison.

In search of that factor, brief consideration of the comparative development of the senses of birds may indicate the more probable nature of that factor. Undoubtedly, birds possess great acuteness of hearing; but although this avails some of them in their search for some insects, in our experiments it could not have influenced their choice among insects already dead. Keenness of sight, and habitual awareness of the minute visible details of their environment, rather than fineness of perception by smell or taste, are usually conceded to birds. It is true that in the progress of the experiments it was not a rare event to find upon the tray several insects which had been picked up, pinched or even mutilated and partly eaten, and then dropped upon the tray again. Sometimes this occurred with insects of undoubted acceptability; sometimes, with insects usually refused or accepted after delay; but in general, the order of acceptance or the eventual refusal of insects was *not* based upon any preliminary tasting by the birds at the time of experiment. The dropping of mutilated insects, unconsumed, was sometimes traceable to hasty departure from the tray through alarm at the approach of other birds; and in comparatively few instances did the behaviour of the birds suggest to the observer their experimental discovery of distasteful qualities. Some of these instances will be noted on subsequent pages.

Sight, then, would seem to be the sense usually concerned, in determining relative acceptability; and unless we admit the probability that birds distinguish and remember all the hundreds of insect species from which they select their prey, in many cases we must exclude insect form and texture as the basis of visual discrimination; for among the moths and beetles used in the experiments, no differences of this nature, separately characteristic of the two groups—those readily accepted, those usually refused—seemed to exist.

This points to colour or colour-pattern as a probable determinant of relative acceptability, with the obvious inference that in some distinctiveness or conspicuousness of colour or of coloration we may find a clue to the observed discrimination. It may not be true, that the colour sense of birds is in all respects comparable with our own; but if we find some prevailing types of coloration prevalent among the insects usually refused by the birds, and that these colour-types are generally absent among those insect species which they most readily accept, this would seem to constitute evidence significant of a correlation between coloration and relative acceptability. How definitely that correlation is evidenced by the insects used in these experiments, will become apparent by examination of the 31 species represented by 423 insects included in Section III of the List—those insects showing an acceptability rating of 0–25, and most of which are accurately represented in colour on Pl. XVIII.

Lepidoptera, Coleoptera, and Hemiptera of Section III, Acceptability Ratings 0–25, Classified According to Coloration. Figure References are to Coloured Plate XVIII.

	No. of experiment.	No. of insects.	Left on tray.	Rating.
A. Insects conspicuously marked with yellow, orange, or red :				
Scepsis fulvicollis, Hbn. (f. 14)	8	13	12	3·8
Lycomorpha pholus, Dru. (f. 10)	1	1	1	0·0
Hypoprepia miniata, Kby. (f. 11)	9	10	8	8·1
Eubaphe aurantiaca, Hbn. (f. 12)	14	25	16	14·0
Haematopis grataria, Fabr. (f. 19)	2	2	1	8·5
Malthaca dimidiata, H.S. (f. 9)	3	5	4	10·8
Synanthedon sigmoidea, Beut. (f. 17)	4	19	17	8·4
Atteva aurea, Fitch (f. 16)	1	1	1	0·0
Necrophorus americanus, Oliv. (f. 21)	2	2	2	0·0
Necrophorus orbicollis, Say	3	3	3	0·0
Necrophorus pustulatus, Hersch.	2	2	2	0·0
Calopteron reticulatum, Fabr. (f. 7)	9	47	41	7·3
Chauliognathus pennsylvanicus, De G. (f. 8)	1	5	5	0·0
Nacerda melanura, L.	1	1	1	0·0
Epilachna borealis, Fabr. (f. 23)	3	20	20	0·0
Tetraopes tetraophthalmus, Frst. (f. 3)	13	95	92	3·1
Crioceris duodecimpunctata, L.	2	29	27	3·0
Labidomera clivicollis, Kby. (f. 5)	4	14	13	1·3
Lygaeus kalmii, Stal. (f. 2)	9	27	27	0·0
		321	293	
B. Insects exhibiting these colours, but less conspicuously :				
Ammalo tenera, Hbn.	1	1	0	7·0
Photinus consanguinius, Lec.	3	7	7	0·0
Photuris pennsylvanica, De G. (f. 18)	9	9	6	12·7
Trirhabda canadensis, Kby. (f. 20)	1	5	5	0·0
		22	18	
C. Insects brilliantly metallic and polished :				
Chrysochus auratus, Fabr. (f. 4)	4	22	22	0·0
D. Insects exhibiting other types of coloration :				
Tropaea luna, L.	1	1	0	12·0
Callopistria mollissima, Gn.	1	1	0	21·0
Eulype hastata, L.	1	1	0	18·0
Harpalus caliginosus, Fabr.	1	1	1	0·0
Epicauta marginata, Fabr. (f. 22)	7	50	46	3·0
Epicauta pennsylvanica, De G.	1	1	1	0·0
Trox unistriatus, Beauv.	3	3	2	4·0
		58	50	
Totals		423	383	

In the preceding table classifying by coloration the insects of Section III, 343 of the total of 423 insects are included in the two divisions, A and C (insects conspicuously patterned in yellow, orange, or red, and insects brilliantly metallic in coloration). That is, 81% of these insects having low acceptability ratings exhibit one or the other of these two types of coloration; and *not one of the 90 species and 2409 insects* of Section I of the List (insects fully acceptable) conforms to either of these types of coloration in its resting attitude. This justifies the statement that under the conditions of experiment and with these birds and insects, coloration (or undetected characters correlated with coloration) often *determines the relative acceptability* of insects otherwise fairly comparable; and that usually the less acceptable species are those exhibiting in bold patterns with other colours, either yellow, orange, red, or those possessing a brilliantly metallic lustre.

This conclusion is not endangered by the fact that a few species whose coloration is not of that character yet have found place in Section III; for most of them (5 of the 7 species in Division D) are represented in the tabulation by single insects, whose low rating may well be purely accidental; nor is it to be inferred that all the other insects in this tabulation (Section III) would certainly retain that position if employed more numerously and in a greater number of experiments.

If acceptability is relative, and if coloration has an important part in determining relative acceptability, we should find in Section II (insects with ratings 25–60) some insects whose coloration conforms to or approximates that typical of the less acceptable ones. Considering the included species of this section, one by one, we find eight which to a greater or less degree exhibit patterns of yellow, orange, red, or extensive metallic markings.

Insects of Section II, with coloration approximating that of Section III, Divisions A or C (yellow, orange, red, extensively metallic).

	No. of insects.	Rating.
Eubaphe opella, Grt. (ARCTIIDAE)	121	38·1
Euchaetias egle, Dru. (ARCTIIDAE)	5	36·6
Utetheisa bella, Linn. (ARCTIIDAE)	3	25·0
Callopistria monetifera, Gn. (NOCTUIDAE)	1	36·0
Cantharis rotundicollis, Say (CANTHARIDAE)	8	25·3
Cantharis sp. (CANTHARIDAE)	10	44·2
Cyllene robiniae, Frst. (CERAMBYCIDAE)	13	30·7
Judolia cordifera, Oliv. (CERAMBYCIDAE)	2	38·5

These 163 insects received an average acceptability rating of 36·9, in contrast with that of 78·6 credited to the 2409 insects of Section I.

By direct comparison of the insects of Section III with those of Section I, it has not become apparent that coloration other than the yellow-orange-red or the metallic types materially contributes toward low acceptability ratings; but to our eyes some other coloration-types appear equally conspicuous. Most of the insects used in the experiments and which to us seem to depart from the unobtrusiveness which characterises the great majority of these species, find their places in some one of these groups.

Insects entirely white or nearly so.

	No. of insects.	Rating.
Diacrisia virginica, Fabr. (ARCTIIDAE)	5	71·4
Hyphantria cunea, Dru. (ARCTIIDAE)	16	51·1
Estigmene congrua, Wlk. (ARCTIIDAE)	3	51·6
Euproctis chrysorrhoea, Linn. (LYMANTRIIDAE)	1	50·0
Stilpnotia salicis, Linn. (LYMANTRIIDAE)	3	57·3

These 28 insects (all Lepidopterous) show an average rating of 55·4, and in size they are not below the average of the 1560 insects of the same Order included in Section I, with an average rating of 78·5. In so far as we may attach significance to the experiments with this smaller number of white insects, to that extent we may consider this difference of 23 in average rating to be an indication of a slowing-up in acceptability for this type of coloration.

Black and white in conspicuous pattern.

	No. of insects.	Rating.
Ecpantheria deflorata, Fabr. (ARCTIIDAE)	3	94·6
Cerura borealis, Bdv. (NOTODONTIDAE)	3	57·3
Desmia funeralis, Hbn. (PYRALIDAE)	4	36·8
Eulype hastata, Linn. (GEOMETRIDAE)	1	18·0

Contradictory in detail, though the average is almost identical with that of the preceding tabulation. Perhaps the high rating of *deflorata* is accidental.

Pink and pale yellow.

	No. of insects.	Rating.
Anisota rubicunda, Fabr. (CERATOCAMPIDAE)	7	36·1
Rhodophora florida, Gn. (NOCTUIDAE)	11	31·7
Derrima stellata, Wlk. (NOCTUIDAE)	6	25·1

The second of these three insects is often cited as a remarkable example of special protective resemblance, for its daytime resting place is the fading flower of *Oenothera*, with which its colours are in exact agreement. I am unable to ascribe similar significance to the coloration of the other two insects. Here again we find the average acceptability rating far below that of most moths of similar size.

"Dead grass" pattern of the genus Apantesis (ARCTIIDAE).

	No. of insects.	Rating.
Apantesis nais, Dru. & *A. vittata*, Fabr.	25	68·8
Apantesis intermedia, Str.	4	39·7
Apantesis arge, Dru.	3	46·3

Away from their usual daytime habitat, these insects are conspicuous. Of those listed, the largest and most brilliantly coloured is also the one showing the lowest rating of acceptability.

Insects of procryptic coloration in daytime resting attitude, conspicuous in flight.

	No. of insects.	Rating.
Smerinthus geminatus, Say (SPHINGIDAE) . .	3	100·0
Paonias excaecata, A. & S. (SPHINGIDAE) . .	49	93·0
Paonias myops, A. & S. (SPHINGIDAE) . .	9	99·2
Paonias astylus, Dru. (SPHINGIDAE) . . .	7	96·5
Automeris io, Fabr. (SATURNIIDAE) . . .	11	82·7
Catocala (4 sp.) (NOCTUIDAE)	6	84·6
Euparthenos nubilis, Hbn. (NOCTUIDAE) . .	5	96·0

A glance at the ratings of these ten species is sufficient to show that under conditions which render their concealing coloration ineffective, this type exerts no deterring influence. With the five species possessing conspicuous ocellate markings (at rest concealed beneath the forewings), pains were taken that some should be displayed upon the tray with these ocelli in full view; but not the slightest evidence was detected of alarm, delay or avoidance on the part of the visiting birds. Similarly, the brilliantly coloured secondaries of *Catocala* and *Euparthenos* did not interfere with the ready acceptance of these insects. The frequently observed behaviour of a bird in persisting in attack upon some selected insect (of any acceptable species), often following it when upon being pecked it fell from the tray to the ground, and making search for it there, even when scores of other insects just as desirable were within reach, gives apparent confirmation to an interpretation of such coloration in quick-flying insects, which ascribes to it some protective value through making possible an instantaneous loss of identity and consequent baffling of pursuit, in the contrast between activity and conspicuousness, immobility and concealment, or the reverse.

Of the insects experimented with, the series of coloration-types just given consideration include most of those which may be classified on the basis of conspicuousness and of identity or resemblance in coloration. It will appear later that butterflies in general, as they had part in the experiments, exhibit a lower degree of acceptability than moths; and further reference to Sections I, II, and III of the List will indicate that similar differences, apparently based on neither size nor coloration, may be observed among other groups. For example, the GEOMETRIDAE as a group seem to be relatively less acceptable than the NOCTUIDAE. This will become evident by the following comparison of the records of these insects, compiled from Sections I, II, and III of Appendix C.

	NOCTUIDAE.		GEOMETRIDAE.	
	Species.	Average acceptability.	Species.	Average acceptability.
Section I . . .	36	80·8	8	75·9
Section II . . .	13	43·1	16	43·1
Section III . . .	1	21·0	2	13·2
	50	69·8	26	50·9

This shows that of the NOCTUIDAE, nearly three times as many fall to Section I as to Section II; of the GEOMETRIDAE, twice as many to Section II as to Section I; and the average acceptability of the Noctuids exceeds that of the Geometrids by almost 20. As suggestions in explanation, perhaps the relatively smaller wing area and heavier bodies of the NOCTUIDAE render them the more attractive, just as size alone has been shown to influence choice; or perhaps the birds have become accustomed to picking up the more sluggish NOCTUIDAE, and to the frequent escape of the more alert GEOMETRIDAE, and hence are discouraged against attack upon the latter when more promising prey is available.

Avoidance through anticipation of failure may explain the comparatively low rating of the abundant and dull-coloured Noctuid, *Caenurgia erechtea*, Cram. (63·8, as determined by 21 experiments with 62 insects of this species). Alert by day and flying from tussocks and meadowland at the slightest alarm, this must be a familiar insect to ground-feeding birds; and its size, form, and coloration would seem to place it with many others of its family which give evidence of materially higher relative acceptability.

In the preceding tabulations of these experiments, butterflies were usually and purposely omitted; for they were not readily obtainable in adequate numbers and variety, and it also was apparent that in comparison with moths they were not so generally and promptly acceptable. As a matter of record, and to give opportunity for comment on a few of the species, a tabulation of all the butterflies used in the experiments now follows :—

FEEDING-TRAY EXPERIMENTS WITH BUTTERFLIES.

Name.	Experiments.	Insects on tray.	Of this species.	Acceptability.	Left on tray.	Bird visitors.
Papilio glaucus, L. . .	1	67	1	35·0	0	1, 2, 5, 7
Papilio troilus, L. . .	1	50	1	100·0	0	2, 5, 7
Pieris rapae, L. . . .	1	85	11	0·6	10	*1*, 3, 5
Danaida archippus, Fabr. .	5	383	6	33·1	3	1, 2, 3, 4, *5*, 7, 10
Cissia eurytus, Fabr. . .	2	141	6	18·3	0	1, 2, *4*, 5, 7, 8, 11
Argynnis cybele, Fabr. .	1	67	1	100·0	0	2, 7
Phyciodes tharos, Dru. .	2	134	9	11·0	6	*1*, 2, 3, *4*, 5, 7, 8
Vanessa atalanta, L. . .	4	342	4	63·7	0	1, 2, 4, 5, 7
Vanessa virginiensis, Dru. .	3	199	7	52·7	0	1, 2, 3, 4, 5, 7
Vanessa cardui, L. . .	3	218	9	56·4	0	1, 2, 4, 5, 7
Basilarchia astyanax, Fabr.	1	36	1	0·0	1	1, 2
Basilarchia archippus, Cram.	1	67	1	63·0	0	1, 2, 4, 5, 7
Epargyreus tityrus, Fabr. .	2	152	4	79·0	0	1, 2, 3, 5, 7
Thanaos juvenalis, Fabr. .	2	146	14	43·7	0	1, 2, *4*, 5, 11
Poanes hobomok, Harr. .	1	92	1	5·0	0	1, 2, *4*, 11
			76	37·3	20	

Some of these ratings are undoubtedly accidental and resultant from the small number of insects involved. It seems significant, however, that this tabulation, in its general results, indicates that butterflies are less promptly accepted than moths; for the 76 butterflies show an average acceptability rating of 37·3, while all the moths, 2445 in number, show an average rating of 65.

With reference to *Danaida* (supposedly "protected"), three out of six were taken from the tray. In one of these instances the bird taking the butterfly was not identified, nor was the insect actually observed to be eaten; in another experiment, a robin (*Turdus migratorius*, Linn., TURDIDAE) carried a *Danaida* from the tray to the ground, pecked and battered it about for a long time in efforts to dismember it, then flew away leaving uneaten the thorax of the butterfly with the wings attached; in the third instance, again, a robin carried a *Danaida* to the ground, battered it vigorously, then when alarmed by the approach of another bird, flew with the butterfly in its beak, and the final disposition of the insect was not determined. Three other insects of this species were left upon the tray uneaten, through prolonged visits by towhees (*Pipilo erythrophthalmus*, L., FRINGILLIDAE), song sparrows (*Melospiza melodia*, Wils., FRINGILLIDAE), blue jays (*Cyanocitta cristata*, L., CORVIDAE), robins (*Turdus migratorius*, L., TURDIDAE), catbirds (*Dumetella carolinensis*, L., MIMIDAE), and bob-whites (*Colinus virginianus*, L., PERDICIDAE). One inference seems to be that the robin perceives nothing strongly deterrent in this insect, in the process of preparing it for swallowing.

In so far as a single experiment may be considered indicative, it would seem that *Pieris rapae* is not acceptable to some of these birds. Of 11 of these insects used in the experiments, 10 were left upon the tray after having been exposed to the visits of towhees, blue jays, and robins for $2\frac{3}{4}$ hours, though in the early part of this period every one of the 26 moths put out with them was eaten. At the termination of the experiment, 7 of these butterflies showed mutilations or other evidence of having been picked up by the birds and then dropped.

The thick-bodied and moth-like Hesperiid, *Epargyreus tityrus*, (acceptability rating 79) was accorded the same prompt acceptance usually accorded Noctuids and Notodontids of similar size.

By considering the insects of these experiments by groups, we have shown that *size* has a measurable effect upon relative acceptability; that insects, exhibiting certain types of coloration are usually refused; and that other types of coloration, and factors not so surely definable, contribute to a gradation of acceptability, from the few and the less acceptable to the many and the fully acceptable. These conclusions find further and convincing confirmation in the records of individual species, some of which will be set forth in the following pages.

Tetraopes tetraophthalmus, Frst. (Coleoptera, CERAMBYCIDAE).

Acceptability rating, 3·1.

(Pl. XVIII, fig. 3; Pls. XX–XXII; Appendix A, pp. 372, 374–377.)

In 13 experiments, after 189 visits by birds of 9 species, 92 out of 95 *Tetraopes* remained upon the tray uneaten. Among the 680 insects in competition with *Tetraopes* in these 13 experiments, these beetles of fairly comparable size were included:

	In competition with *Tetraopes*.	Eaten.
Small Elaters	33	29
Serica, 2 sp. (SCARABAEIDAE) . . .	66	63
Diplotaxis sordida, Say (SCARABAEIDAE) .	41	39
Dichelonyx elongata, Fabr. (SCARABAEIDAE).	10	10
	150	141
Tetraopes tetraophthalmus, Frst. . . .	95	3

That is, of 150 beetles of comparable size, 94% were eaten; and of *Tetraopes*, only 3% were eaten, in the same set of experiments. No further experiments with this insect were deemed necessary, to establish the fact of its avoidance, amounting practically to its refusal, by these birds. Throughout its life-cycle associated with the plant genus *Asclepias* (Pl. XXVIII), this abundant insect rests, feeds, mates, in full view upon the leaves and flowers of its food-plant, and distributes itself in clumsy daytime flight to other herbage. Thus conspicuous by habit as well as by its coral red and black coloration, there are few insects of midsummer more familiar, so that any avoidance of *Tetraopes* by birds can scarcely be attributed to its strangeness to them.

In so far as the records of the U.S. Biological Survey relating to the food of birds as ascertained by stomach examinations have been made available by publication up to the present year, they give support to the belief that this insect is usually avoided by insectivorous birds. After somewhat careful search of that literature, I find *four* references to the acceptance of *Tetraopes* by birds; by the examination of 2466 stomachs of the (introduced) starling, more than 8000 beetles of 27 families were approximately identified in its food, most of them specifically; yet of this great number, only *two* stomachs were found to contain this abundant widely-distributed genus of daytime conspicuousness, *Tetraopes*. In the food of the bluebird, as determined by the examination of 855 stomachs, it was found in 4. In the food of the crow, determined by 2118 stomach examinations, it is listed without statement of frequency, and similarly in the food of the bob-white. It does not occur (Bulletin 171) in the tabulated food of the robin (1236 stomachs), nor among the 32 families of the Coleoptera, including 48 species of the CERAMBYCIDAE, listed (Bulletin 1355) in the food of the vireos, as determined by the examination of 1951 stomachs; yet of the CERAMBYCIDAE, surely *Tetraopes* is scarcely exceeded in daytime availability by other species of the family. Dr. W. L. McAtee has just published a long paper (" Effectiveness in nature of the so-called protective adaptations in the animal kingdom," etc., March 15, 1932, *Smithson. Misc. Coll.*, **85**: 1–201) dealing especially with the food habits of Nearctic birds; and although his conclusions are opposed to any interpretation of insect coloration which assigns to it significant protective value of *Tetraopes*, his figures do not materially change those already quoted. His tabulations are based upon 237,000 identifications of food in the stomachs of 80,000 birds; and in this great number, *Tetraopes* occurs only nine(!) times. This present evidence, both of experiment and by stomach examinations, seems to me in accord with the view that *Tetraopes* is definitely avoided by most bird species which habitually prey upon related insects of similar size.

Calopteron reticulatum, Fabr. (Coleoptera, LYCIDAE).

Acceptability rating, 7·3.

(Pl. XVIII, fig. 7; Pls. XXII, XXIV; Appendix A, pp. 377, 378.)

In 9 experiments, after 141 visits by birds of 7 species, 41 out of 47 of these insects remained upon the tray uneaten. Of 519 insects in competition with *Calopteron* in these 9 experiments, the following insects of the same Order, most of them fairly comparable in size, were included :

	In competition with *Calopteron.*	Eaten.
Harpalus pennsylvanicus, Say (CARABIDAE) .	34	34
Small Elaters	20	20
Serica, 2 sp. (SCARABAEIDAE) . . .	49	48
Diplotaxis sordida, Say (SCARABAEIDAE) .	11	10
Phyllophaga & *Polyphylla* (SCARABAEIDAE) .	43	43
	157	155
Calopteron reticulatum, Fabr. . . .	47	6

That is, of 157 beetles of acceptable species, 98·7% were eaten; of *Calopteron*, in the same experiments, 12·8% were eaten. Of the six insects of this species taken from the tray, four were taken in a single experiment and in a period when the only bird visitors were blue jays (*Cyanocitta cristata*, L., CORVIDAE). Perhaps all four were taken by the same bird.

This showy black and yellow beetle, carnivorous by habit, makes itself conspicuous upon the upper surfaces of leaves in the more open forest and along wood-margins and paths. It is sluggish in habit, slow in daytime flight, and usually it may be picked from its resting-place without making any attempt to escape. I do not find this species or genus listed in the published records of the food of birds as determined by stomach examinations and as already referred to under *Tetraopes*.

Labidomera clivicollis, Kirby (Coleoptera, CHRYSOMELIDAE).

Acceptability rating, 1·3.

(Pl. XVIII, fig. 5.)

In the four experiments in which *Labidomera clivicollis* had part, about half of the 220 insects in competition were Lepidoptera, about half Coleoptera including several species (of which all were eaten) fairly comparable in size with this insect. In the course of the four experiments, blue jays (*Cyanocitta cristata*, L., CORVIDAE) made 13 visits; catbirds (*Dumetella carolinensis*, L., MIMIDAE) made 10; song sparrows (*Melospiza melodia*, Wils., FRINGILLIDAE) made 57; robins (*Turdus migratorius*, L., TURDIDAE) made 8; towhees (*Pipilo erythrophthalmus*, L., FRINGILLIDAE) made 22 visits; all without taking a single insect of this species from the tray. Of the 14 insects of this species included in the experiments, only one was accepted, and that one was taken by a bob-white (*Colinus virginianus*, L., PERDICIDAE). This showy orange and black beetle feeds by day upon the foliage of *Asclepias*, upon which it passes its early stages as well. It is sluggish in habit and though far from rare it is not often seen far from its food-plant.

Chrysochus auratus, Fabr. (Coleoptera, CHRYSOMELIDAE).

Acceptability rating, 0.

(Pl. XVIII, fig. 4; Pl. XXII; Appendix A, pp. 376, 377.)

This insect was used in four experiments, in competition with a total of 208 insects, of which 194 were Coleoptera. These experiments included other relatively unacceptable species which too were left upon the tray; but of 8 species represented by 107 beetles, 103 were eaten, while all of the 22 of this species were left. That is, 96% of 8 species were eaten, *none* of *Chrysochus*.

This gorgeously coloured insect, brilliant metallic green with bronzy reflections, though usually a common species, seems to be of infrequent occurrence on Martha's Vineyard (I found it there but once, and that at several miles distance from the place of experiment), so it may well have been entirely strange to the four bird species which in 130 visits failed to accept it. *Chrysochus auratus* feeds in scattered colonies on the foliage of the dogsbane (*Apocynum*). When disturbed, it does not usually attempt to escape by flight, but releases its hold upon the herbage and falls to the ground. For opportunity to use it in these and other experiments, I am indebted to Mr. Henry Bird of Rye, New York, who supplied me with live material and who witnessed some of these experiments.

Necrophorus, three species (Coleoptera, SILPHIDAE).

Acceptability rating, 0·0.

(*N. americanus*, Oliv., Pl. XVIII, fig. 21.)

Seven insects of this genus, belonging to three species (*americanus*, Oliv., *orbicollis*, Say, and *pustulatus*, Hersch.), were used in three experiments in competition with 171 insects, 112 of them coleopterous. *None* of these conspicuous black and orange beetles were eaten, while of 46 other beetles of comparable size (7 species), 42 were eaten in 93 visits by birds of 7 species. "Burying beetles" must be familiar to most ground-feeding insectivorous birds and they have been recorded among the usual food of several species—especially of the crow, which to some extent feeds upon carrion; but these experiments seem to indicate an avoidance of these insects (at least when other food is available) by the birds which visited the tray.

Scepsis fulvicollis, Hbn. (Lepidoptera, SYNTOMIDAE).

Acceptability rating, 3·8.

(Pl. XVIII, fig. 14; Pl. XXIII; Appendix A, p. 379.)

In 8 experiments, after 216 recorded visits by birds of 8 species, 12 out of 13 of these insects remained upon the tray uneaten. In these 8 experiments, *Scepsis* was in competition with 467 insects, which included many small Noctuids and Geometrids of prompt acceptance. Of insects smaller than *Scepsis*, hence on the basis of size less acceptable, the Pyralid, *Nomophila noctuella* was used in five of the eight experiments and to the number of 38. Of these, 35 (92·1%) were eaten, in comparison with 1 of the 13 *Scepsis* (7·8%) taken from the tray in these same experiments.

Scepsis fulvicollis, fuscous bluish-purple (in age, fading to smoky brown) with head and collar bright orange, flies freely but slowly by day, frequenting low herbage and flowers, especially yellow or white composites, upon which its coloration makes it a conspicuous object. It is not a rare insect and is sometimes very abundant locally.

Hypoprepia miniata, Kirby (Lepidoptera, LITHOSIINAE).

Acceptability rating, 8·1.

(Pl. XVIII, fig. 11; Pl. XXIII; Appendix A, p. 379.)

This species was used in 9 experiments, the total number of insects in competition being 545. These consisted mostly of Lepidoptera, many of them being

Noctuids, Geometrids, Pyralids, of size fairly comparable with *miniata*. Of the total number in competition with *miniata*, 92% were eaten in 357 visits by birds of 6 species, and 8 of the 10 *miniata* were left upon the tray. This brilliantly coloured insect (grey, streaked with orange and scarlet) is a night-flying species, sluggish in daytime habit. Ordinarily it is not an abundant insect, though not rare in suitable habitat.

Synanthedon sigmoidea, Beut. (Lepidoptera, ÆGERIIDAE).

Acceptability rating, 8·4.

(Pl. XVIII, fig. 17.)

Through the kindness of Mr. George P. Engelhardt, a specialist in the AEGERIIDAE, I was able to use this wasp-like black and yellow Aegeriid in a number of experiments. In view of the supposed mimetic relationship between many of the AEGERIIDAE and the stinging Hymenoptera, the results are most interesting. Among the 195 insects competing in 4 experiments, 19 of this species were included, together with other Lepidoptera of similar size but of inconspicuous coloration, and several species of the stinging Hymenoptera it has been supposed to mimic, with these results :—

Synanthedon sigmoidea, placed on tray, 19; eaten 2
Nomophila noctuella, ,, ,, ,, 36; ,, 34
Vespa and *Polistes*, ,, ,, ,, 14; ,, 4

Of the 129 Lepidopterous insects other than *Synanthedon* included in these four experiments, 92% were eaten by birds of five species, which made a total of 128 visits to the tray. In so far as these experiments give indication, *Synanthedon* is not recognised by birds as more acceptable than the stinging Hymenoptera which it resembles in form and coloration.

Lygaeus kalmii, Stal. Hemiptera, LYGAEIDAE).

Acceptability rating, 0·0.

(Pl. XVIII, fig. 2; Pls. XX, XXI, XXII; Appendix A, pp. 372, 374, 377.)

In 9 experiments, with 482 insects in competition, not one insect of this species (out of a total of 27) was eaten, though six species of birds made a total of 233 visits to the tray. Unfortunately no other insects of this order were included in these 9 experiments, though Pyralids and other small Lepidopterous insects were present, and small beetles to the number of 103. Of these beetles (*Serica*, *Dichelonyx*, *Diplotaxis* of the SCARABAEIDAE, *Capnochroa* of the ALLECULIDAE, and small Elaterids) 93% were eaten in these same experiments, in which no *Lygaeus* was taken from the tray. Published records of stomach contents often show a considerable proportion and variety of the Hemiptera in the food of insectivorous birds, so failure to accept this species cannot be attributed to a general avoidance of the order; nor up to the present year do I find this species named in the published tabulations of such studies; however, in Dr. McAtee's paper of 1932, to which reference (p. 358) has already been made, this species may be one of those included in his statement that " the large red and black *Lygaeus* species were taken by 14 species of birds."

L. kalmii, black and scarlet, is a long-lived and abundant insect, conspicuous in daytime habit as an associate of *Asclepias*, and often met with on low herbage away from that plant.

Epicauta cinerea marginata, Fabr. Coleoptera, MELOIDAE).

Acceptability rating, 3·0.

(Pl. XVIII, fig. 22; Appendix A, p. 378.)

In 7 experiments involving 149 visits by birds of 7 species, 50 of these "blister-beetles" were used in competition with 363 other insects. Of this species, only 4 of the 50 (8%) were eaten; of 77 other beetles of 12 species, 96% were eaten. Of the 4 blister-beetles eaten, 3 were taken in a single experiment and in a period when the tray was crowded by a family of blue jays (*Cyanocitta cristata*, CORVIDAE) including young just learning to feed themselves.

Consideration of this insect has been deferred to the last of the ten species receiving separate attention here, not because the evidence of its usual refusal by the birds is less conclusive, for no one could witness these experiments without recognising that it is definitely discriminated against; but because it alone of the ten does not conform to a type of coloration which so often characterises the less acceptable species. Whether this avoidance is due to a memory of past experience (with young birds, to example and instruction?) involving the identification of an insect which to us is not especially distinctive in form or coloration, or whether its avoidance may be otherwise explained, is not apparent from these experiments. The strongest support I have been able to find for this possibility of specific identification by the birds, occurs among those records which have been frequently quoted in opposition to a belief in the protective value of insect coloration: In the published records of the U.S. Biological Survey may be found these references to the selection of (stingless) drone honey-bees in preference to workers of the same species:

	Bird species.	Stomachs examined.	Honey-bees found.	Of these, drones.
In *Biol. Surv. Bull.* **44**.				
Page 13	Kingbird	665	61	51
Page 20	Ark. Kingbird	109	31	29
In *Dept. Agr. Bull.* **619**.				
Page 3	Purple Martin	205	11	11
Page 8	Cliff Swallow	375	35	35
		1354	138	126

The author of these two Bulletins, Mr. F. E. L. Beal, adds this comment (*Bull.* **619**: 9): "When it is considered that the worker bees in the hive far outnumber the drones, it is evident that the foraging birds must meet many workers where they encounter a single drone. Evidently the drones are deliberately selected. . . ." If Mr. Beal is correct in his interpretation of these conditions, then this record not only confirms the ability of the birds to remember and distinguish between insects of the same general appearance and lacking distinctive coloration, but they also carry the implication that the stings of the worker bees are recognised by these birds as a fairly adequate defence.

This genus *Epicauta* and its family the MELOIDAE also illustrate a condition not unusual regarding many insect groups, in that some of the proponents of "protection" have contended that these insects enjoy almost complete immunity from attack by vertebrate predators, while opponents of that belief produce evidence that they are regularly preyed upon by some bird species and are eaten at least occasionally by a considerable number of others. In this connection it is perhaps significant to quote once more from Mr. F. E. L. Beal (*U.S. Biol. Survey Bull.* **44**: 12), who writes of the kingbird (*Tyrannus tyrannus*) :—

> " Perhaps the most surprising and unexpected components of this bird's food are the blister beetles. They appear in the food to some extent in every month in which stomachs were collected . . .; and in September, when 46 stomachs were taken, they amount to 11·55 per cent. of the whole food for that month. . . . It seems hardly credible that a bird could eat without harm an insect that causes a blister when crushed upon the human skin, but that this bird does eat them, and apparently as many of them as it can get, is shown by the fact that 8 of these beetles were found in one stomach, 10 in another, 11 in each of 2 others, 13 in each of 4, and 14 in another. They were found in 70 stomachs, or over 11 per cent. of the whole."

Prof. Beal's competence to characterise this condition as " the most surprising and unexpected " is beyond question. Dr. McAtee speaks of him as " the veteran economic ornithologist who has examined the contents of more birds' stomachs than any other person in the world." In contrast with the " surprising " presence of the MELOIDAE in over 11% of the 665 stomachs of kingbirds may be cited an opposite condition revealed by some of the more extensive tabulations from the same authorities : the identified insects from the stomachs of 2118 crows, 2115 starlings, and 1951 vireos, a total of 6184 stomachs, show *one* stomach containing *Epicauta* ; yet these insects are conspicuous in habit, many of them also in coloration, they are daytime feeders, and they are often present on herbaceous vegetation in great numbers. In his later paper (" Effectiveness in nature of the so-called protective adaptations in the animal kingdom, chiefly as illustrated by the food habits of Nearctic birds," Washington, March 15, 1932) Dr. McAtee adds to the published evidence in regard to the MELOIDAE, citing the fact that they have been found in the food of 47 species of (North American) birds, with 10 or more records from each of 7 species.

He finds a parallelism between frequency of predation (as indicated by times identified, *not* by number of individuals eaten) and the theoretical abundance in individuals of the species, genera, or larger groups, based on the proposition that " the number of species in taxonomic groups bears a general relation to the number of individuals " ; and he carries this comparison through the orders and families of insects at great length and with varying success. By his table of the families of Coleoptera (pages 65–67 of his paper), his records for the MELOIDAE indicate predation to about one-fourth the degree called for by his estimate of the relative abundance of individuals of this family ; while in the SCARABAEIDAE, for example, these conditions are reversed, and the recorded predation is nearly three times as great as that indicated by theoretical abundance in that family, This would seem to indicate that under conditions of similar abundance, a Scarabaeid has about eleven times as great a chance of being eaten, as a Meloid, which is certainly not in line with his conclusions ! Dr. McAtee makes plain his attitude that his methods of comparison involve many inconsistencies and inaccuracies in detail, and that they can be interpreted only as a " fair working idea " and in the most general way. Whatever evidential value those comparisons may possess, here (and in many other instances) they seem to leave abundant margin for the operation of " so-called protective adaptations."

The results of stomach examinations, as assembled and ably presented in Dr. McAtee's paper, surely indicate that many "so-called protective characters," at most, can be only relatively efficacious. Experiment indicates that acceptability is relative, through a wide range of degree. Belief in the protective value of a character is not invalidated by evidence that it is occasionally disregarded by many enemies, or even that it is totally disregarded by a few; for it may still be one of the many factors involved in the equilibrium of survival. From this viewpoint I think there is no irreconcilable conflict between the published records of stomach examinations of North American birds, and the general results of these experiments.

In these experiments, although they demonstrate a wide range of relative acceptability among the insects involved, and although in most instances certain types of coloration are shown to be associated with the minimum of acceptability by no means has it been made apparent that coloration is the basic cause of the discrimination exhibited by the birds. In most instances it seems safe to conclude that avoidance is not due to fear, for often the accepted and the refused insects were crowded upon the tray in actual contact with one another, and the picking up and dropping of unacceptable insects, as well as the fully acceptable ones, was not a rare occurrence. In many instances, avoidance can scarcely be ascribed to strangeness or unfamiliarity; for some of the insects most uniformly discriminated against are among the more abundant and conspicuous species within the customary feeding range of the birds, and in many instances a habit of conspicuousness—of all avoidance of concealment—is associated with conspicuousness of coloration; and one or both of these characters usually marks those species which are the less acceptable to the birds. In itself, aversion to certain colours cannot be a reason for avoidance; for these same colours characterise many ripening fruits which are eagerly sought after and eaten by the birds. The colour sense of birds, as it might affect distinctness of vision, can scarcely be assigned as a reason for avoidance; for experimental evidence indicates that their vision is especially keen toward the red end of the spectrum. Unacceptability through distastefulness—through the possession by the insects of nauseous or even of poisonous secretions—and warning coloration correlated with these conditions, offers a logical explanation of the phenomena; but comparative unacceptability through distastefulness is most difficult of proof, and we may easily err in our efforts to interpret the behaviour-response of birds to food made available to them.

The experiments now to be described are an attempt to demonstrate the possession of distasteful or possibly of poisonous qualities in some of the insects avoided by the birds, and in a manner which eliminates the colour factor from the problem. That the experiments are based upon the reactions of life-forms widely unrelated to birds removes them from the status of direct and positive evidence; but their significance is broadened by some unanticipated results which open up possibilities giving new significance to some phases of insect coloration in relation to environment.

The suggestion for these experiments arose through an accidental observation made early in the year 1930 at Royal Palm State Park in extreme southern Florida. Having occasion to leave the work-table upon which I had spread out a number of freshly killed insects, on my return after an interval of several hours I found that many of the insects I had left were being hollowed out and dismembered by swarms of small ants, but that certain other insects on the same table were undisturbed. The identities of the insects thus avoided suggested a definite discrimination against certain species. When, therefore, in the course of the bird-insect experiments on Martha's Vineyard, a discrimination correlated with insect coloration became apparent, it occurred to me that living ants might be used as *indicators of inedibility* in a series of experiments from which the factor of colour could be eliminated. Conceivably, there might be little basis for comparison between the tastes of birds and of ants; but these latter creatures, notoriously sensitive to odours and flavours and even to poisons, might be expected to detect differences not readily determinable by human senses or by chemical examination; and it was hoped, through an agreement between the bird-rejected and the ant-rejected species, that to this extent confirmatory evidence of the real basis for rejection might be secured.

The first experiments were crude attempts to reproduce the Florida conditions, and insects of several species were placed near the ant colony and kept under observation there. Though these experiments bore out the interpretation placed upon the earlier observations, it was soon obvious that differences in texture, the drying up of the smaller insects, and other uncontrollable factors rendered this procedure very unsatisfactory. After several variations in the method of experiment, it was discovered that *infusions* of some of the insects, mixed with food of known acceptability to the ants, would in some instances deter the ants from accepting that food, while infusions of other insects exerted no deterring effect. That is, those insects which the ants refused to eat when offered them entire and in fresh condition were similarly deterrent when introduced into other food-material in the form of infusions, by which latter means all differences of colour and of texture were eliminated from the test.

Nearly all of these experiments were made indoors on the floor of a ground-level room, thus avoiding the delays and irregularities incident to out-of-door experiment complicated by unsuitable weather conditions. Here the ants were always the same species, the small " red " (really yellow) ant, *Solenopsis molesta*, Say, a strong colony of which was always present as a household pest. The test foods were spread upon a white enamelled plate in small numbered areas, and usually the ants discovered the food and visited it in increasing numbers within an hour after its display. By jarring and turning the plate several times in the course of an experiment, the ants were distributed over it and reassembled by new routes, ensuring against advantage of position for any portion of the plate. Thick fresh cream, very attractive to the ants, was found to be a suitable food medium for the tests; and in each series of tests, check tests of cream alone or of cream incorporated with the solvent used for the insects, were included to ensure that no deterring factor was present, other than the infusions of the various insects being tested.

The solvents used were amyl acetate, grain alcohol (these two attractive to ants rather than deterrent), chloroform (repellent until it evaporated from the material tested), and water—these used with the thought that some insect secretions might prove soluble or miscible in one fluid, some in another; but no insect was found whose water extract was not fully as deterrent as that in the other solvents named.

The insects were used either in fresh condition, or dried and kept thus for future use. They were cut or crushed into small fragments, placed in a small clean vial, barely covered with the solvent, and allowed to stand for a few hours. In preparation for a test, a few drops of the insect extract were thoroughly incorporated with a slightly larger quantity of cream and spread in a numbered place upon the plate, with a check test of cream and solvent in some adjacent space.

Usually there was no difficulty in determining whether the ants found these mixtures acceptable or not; and most commonly the numbered spaces containing cream alone, cream with solvent incorporated, and cream with insect extract added, were soon alike swarming with ants in more or less even distribution (Pl. XXV), which did not desist from attack until all the food had been eaten from the plate. In a few instances the behaviour of the ants was so unmistakably different (and these differences confirmed by repeated experiment) that I was encouraged to continue the tests until I had record of a large number of insect species, and had arrived at some results which to me seemed both surprising and significant. In the selection of insects for test I endeavoured to include most of those species which had been avoided by the birds, as well as a representative series of those which had proved to be promptly acceptable to them. In all, insects of four Orders, of thirty-three families, and upward of a hundred species, were tested in this manner.

As these experiments with ants proceeded, it became more and more apparent that no general agreement of results might be expected between the two series of experiments—those with birds and those with ants. In addition to a large number of insects which had proved readily acceptable to the birds and which now proved to be just as acceptable to the ants, may be mentioned the following species, most of which were among those shown to be less acceptable to the birds, but which the ants found fully acceptable:

Lepidoptera.

- DANAIDAE.
  - *Danaida archippus*, Fabr.
- SYNTOMIDAE.
  - *Scepsis fulvicollis*, Hbn.
- LITHOSIINAE.
  - *Hypoprepia miniata*, Kirby.
- ARCTIINAE.
  - *Eubaphe*, 2 sp.
  - *Euchaetias egle*, Dru.
- ZYGAENIDAE.
  - *Malthaca dimidiata*, H.S.
- AEGERIIDAE.
  - *Synanthedon sigmoidea*, Beut.
- YPONOMEUTIDAE.
  - *Atteva aurea*, Fitch.

Neuroptera.

- CHRYSOPIDAE.
  - *Chrysopa* sp.

Coleoptera.

- SILPHIDAE.
  - *Necrophorus* sp.
- LYCIDAE.
  - *Calopteron reticulatum*, Fabr.
- LAMPYRIDAE.
  - *Photinus* and *Photuris*.
- CANTHARIDAE.
  - *Chauliognathus pennsylvanicus*, DeG.
- MELOIDAE.
  - *Epicauta marginata*, Fabr.
- COCCINELLIDAE.
  - *Epilachna borealis*, Fabr.
- CHRYSOMELIDAE.
  - *Crioceris duodecimpunctata*, Linn.
  - *Trirhabda canadensis*, Kirby.

Hymenoptera.

- VESPIDAE.
  - *Vespa diabolica*, Sauss.
- APIDAE.
  - *Apis mellifica*, Linn.

From the foregoing text and from this list it is apparent that the refusal of insects by ants must be of comparatively rare occurrence. Whatever may be the truth in regard to living insects, the total number of dead insects found to possess qualities deterrent to ants is so few, that each species deserves the separate mention which follows:—

Syntomeida epilais, Walk. (Lepidoptera, SYNTOMIDAE).

(Insect, Pl. XVIII, fig. 1; ant experiments, Pls. XXV, XXVI.)

This conspicuous day-flying moth, captured in Florida in February 1930, was one of the species observed there to be avoided by ants. With little expectation that any deterrent qualities would be present in the dead and dried insects, this species was offered the ants (*Solenopsis molesta,* Say) at Martha's Vineyard at intervals up to August 1, 1931, and in every one of eleven experiments, their refusal to eat it was unquestionable. That is, the deterrent in this insect is stable over at least 1½ years. Check tests with insects of other species, captured at the same time and place and preserved in the same boxes, elicited the opposite response of ready acceptance, in the same experiments.

The experiments with *epilais* included all of these methods of submission to the ants :—

The entire insect, dry.
The entire insect, softened in water.
The dry insect, cut into fragments and mixed with cream.
Infusions of the insects in chloroform, in amyl acetate, in grain alcohol, and in water, and small portions of the various liquid extracts incorporated with cream.

With all of these, the response was one of uniform refusal by the ants, up to periods of 44 hours' exposure—the check tests included in the same experiments being consumed within the first few hours of exposure. All the specimens of *epilais* used in these experiments had been netted in daytime flight, and were then in fine freshly-emerged condition.

Lygaeus kalmii, Stal. (Hemiptera, Lygaeidae).

(Insect, Pl. XVIII, fig. 2; ant experiments, Pls. XXVI, XXVII, XXVIII.)

This insect was used in 23 experiments, with some exposures for as long a period as three days; and in 20 of these experiments, its refusal by the ants was complete and unmistakable. The availability of live material of this species made possible its use in both fresh and dry condition, the dry insects retaining their deterrent qualities up to 60 days (not tested for longer periods). The three experiments showing somewhat opposite results were in the use of amyl acetate extracts, though in eight other experiments with this solvent, complete refusal was recorded. Fresh or dry in water, or the insect itself macerated in cream, gave uniform refusals. A single out-of-door test with a larger species of ant (unidentified), using *kalmii* collected and dried sixty days previously, gave a result of complete refusal, the accompanying check test being quickly eaten. In the various solvents mentioned, infusions of this insect are clear and colourless, and no marked odour was detected in them.

Tetraopes tetraophthalmus, Frst. (Coleoptera, Cerambycidae).

(Insect, Pl. XVIII, fig. 3; ant experiments, Pls. XXVI, XXVII.)

This insect was used in 17 experiments and in the varying combinations already described for the other species. Its record was one varying from complete refusal to delayed and partial acceptance. Usually the check tests were cleared from the plate before any considerable number of ants attacked the *Tetraopes* samples; and the hardened cream of *Tetraopes* tests was often slowly pitted and excavated by the ants over a period of several days, leaving a rejected powdery residue. Evidence of the presence of a deterrent was unmistakable; but evidently it is either present in smaller quantity or is less efficacious in nature, than that possessed by *epilais* and *kalmii.* Liquid extracts of this insect are strongly coloured, yellow.

Labidomera clivicollis, Kirby (Coleoptera, CHRYSOMELIDAE).

(Insect, Pl. XVIII, fig. 5; ant experiments, Pl. XXVI.)

The record of this insect in a number of experiments was similar to that of *Tetraopes.* Usually, when partial acceptance occurred, this took place after an exposure of twenty hours or more, in the first few hours of which period the check tests were completely consumed. Like those of *Tetraopes*, its infusions are conspicuously yellow in colour.

Chrysochus auratus, Fabr. (Coleoptera, CHRYSOMELIDAE).

(Insect, Pl. XVIII, fig. 4; ant experiments, Pl. XXVI.)

This insect was used in 12 experiments, the results (as in *clivicollis* and in *Tetraopes*) usually varying from complete refusal to a slow acceptance with a residue uneaten after many hours. The evidence of the presence of a deterrent in all of these insects was unmistakable.

The first of these five insects (*epilais*) was not available at Martha's Vineyard for inclusion in the experiments with birds. The other four, in the bird experiments, received acceptability ratings as follows :—

Tetraopes tetraophthalmus	3·1
Labidomera clivicollis	1·3
Chrysochus auratus	0·0
Lygaeus kalmii	0·0

That is, these four insects, unacceptable to the ants, rank among those least acceptable to the birds. They also rank among the typical examples of conspicuousness of coloration and of daytime habit. As they are thus brought together for consideration as a group, one other fact of possible significance stands out : all four species, in both their immature and their adult forms, feed exclusively upon members of the plant family Asclepiadaceae or upon the closely related Apocynaceae, plants with abundant, acrid, and poisonous milky juices (latex).

In these present experiments it did not clearly appear whether the refusal of these insects by ants is attributable to secretions of the insects themselves, to concentrations in the bodies of the insects of plant-derived deterrents, or simply to the presence of deterring plant material in their digestive tracts. If, however, we consider the entire list of milkweed-feeding insects used in the bird experiments, we find these conditions :—

Danaida archippus, Fabr.	Bird	acceptability,	33·1;	accepted	by ants.
Euchaetias egle, Dru.	,,	,,	36·6;	,,	,,
Ammalo tenera, Hbn.	,,	,,	7·0;	,,	,,
Tetraopes tetraophthalmus, Frst.	,,	,,	3·1;	refused	,,
Labidomera clivicollis, Kby.	,,	,,	1·3;	,,	,,
Chrysochus auratus, Fabr.	,,	,,	0·0;	,,	,,
Lygaeus kalmii, Stal.	,,	,,	0·0;	,,	,,

Of these seven species the first three, *in their larval stages but not as adults*, feed upon milkweeds, and these adults are relatively unacceptable to birds, fully acceptable to ants; the last four, feeding upon milkweeds *both as larvae and as adults*, are refused by both the birds and the ants. While this evidence is circumstantial rather than positive, it strongly suggests that the ant deterrent originates in the food-plant, and that it is not passed along, in quantity sufficient for detection when ants are used as indicators, to the adults of those insects which feed upon these plants in their larval stages only.

This naturally suggested a test of the response of ants to milkweed foliage and milkweed latex. In several such tests, the foliage of *Asclepias syriaca*, Linn. (Pl. XXVIII, 2, 4), fresh or dry, and combined with cream as in the experiments with insects, was not found to exercise any deterring effect upon the ants. The milky juice of this plant, however, when mixed in fresh condition with cream or as an infusion in water of the dried juice, exhibited the same deterring effect (Pl. XXVIII, 1, 2) upon ants of the two species mentioned, as that shown by the milkweed-feeding insects and most strongly evidenced by *kalmii*, which feeds upon the plant juices rather than upon foliage containing those juices.

One further fact should not escape notice here: the prevalence of the yellow-orange-red type of coloration among insects feeding upon *Asclepias* and related plants. In 1921 (*J. N.Y. Ent. Soc.*, **29**: 123–145) Weiss and Dickerson published a paper, "Notes on Milkweed Insects in New Jersey." In addition to the insects I have mentioned, their list includes another Lygaeid bug even more conspicuously coloured than *kalmii*, another Arctiid related to *Euchaetias*, two species of Curculionid beetles, and a few much smaller insects. Of the obligatory associates of *Asclepias* and *Apocynum* in that general region, these species exhibit markedly conspicuous coloration :—

Danaida archippus larva; transversely striped, yellow, black, white.
Euchaetias egle larva; the "Harlequin Caterpillar" of popular literature.
Tetraopes tetraophthalmus; red and black (Pl. XVIII, fig. 3).
Labidomera clivicollis; orange and black (Pl. ,, fig. 5).
Chrysochus auratus; polished metallic green (Pl. ,, fig. 4).
Lygaeus kalmii; red and black . . (Pl. ,, fig. 2).
Oncopeltus fasciatus; orange and black (Pl. ,, fig. 6).

and these, no marked conspicuousness of coloration :—

Rhyssematus (CURCULIONIDAE), 2 sp.; uniformly dull in coloration.
Ammalo tenera larva; described as "mouse colour," feeding at night.

This predominance of gaudy coloration among insects associated with these plants seems scarcely explicable as chance coincidence, and the daytime habit of these insects adds to their conspicuousness. To those mentioned may be added other representatives of the genus *Tetraopes*, of similar coloration and habits; several more orange and black hemipterous insects associated with these plants; *Danaida berenice*, whose conspicuous larva is recorded from both *Asclepias* and *Nerium* (Apocynaceae); and *Nerium* is the usual food-plant of the showy Syntomid, *Syntomeida epilais* (Pl. XVIII, fig. 1), which even in its adult stage is so deterrent to ants! These North American milkweed-feeding insects are incompletely enumerated without special research, and it would be a most interesting study to determine the percentage of "warningly coloured" insects having the Asclepiadaceae and the Apocynaceae as their food-plants, throughout the world. That these colours are a necessary result of feeding upon these plants is denied by the fact that some insects which are their obligatory associates are not thus coloured, and that of those conspicuously coloured, some range through yellow to red in varying combinations with other pigmentary colours, and others exhibit a brilliantly metallic coloration of widely different nature.

"Warning coloration" here, then, seems to be correlated with a poisonous food-plant and the presence of plant-derived poisons in the bodies of these insects. Members of these two plant families are usually avoided by grazing animals, and some of them are known to contain poisons fatal to vertebrates (mammals). To what extent these insects (especially *Syntomeida epilais* and *Lygaeus kalmii*, in which the ant experiments indicate the greater concentrations of the deterrent) may be seriously poisonous to birds, if eaten in quantity, deserves investigation.

Attempts have been made (for example, by Haase, 1891–93 *) to ascribe wide application to the influence of poisonous food-plants as deterrents to vertebrate attack upon insects; but not only have some of these suggestions no apparent basis in fact, but also and more frequently must other factors be the determinants of relative unacceptability. Among the insects which in these experiments seemed the least acceptable to birds may be mentioned *Scepsis fulvicollis*, Hbn. (Lepidoptera, SYNTOMIDAE), whose larva feeds upon grasses; the larvae of three others of the moths feed upon lichens; at least five of the beetles, as larvae, are predacious, and so are several of the adults; others, vegetable feeders, are not confined to single food-plants or plant families, nor do their habits in any way suggest the possession of plant-derived deterrents, which therefore may be regarded as only one of many possible factors influencing the relative acceptability of insects to birds.

Whatever further significance may be attached to these experiments, I believe that they demonstrate—

(*a*) That insect acceptability to birds is relative, and that the causes determining relative acceptability are complex.

(*b*) That insect coloration has material influence upon insect acceptability.

(*c*) That in general, insects with duller colours and obscure patterns are the more acceptable, those with brighter colours and bolder patterns the less acceptable.

(*d*) That those least acceptable are often characterised by conspicuous markings of yellow, orange, or red, or are brilliantly metallic; and that these types of coloration are usually correlated with a daytime habit of display rather than of concealment.

(*e*) That the experiments with ants demonstrate the presence of a deterrent in a few insects, and that while no complete parallelism exists between the tastes of birds and of ants, all of the insects refused by the ants and used in the experiments with birds were among those most consistently refused by the birds.

(*f*) That the food of the insects found to possess these ant-deterrents consists of the leaves and juices of related acrid and poisonous plants; and that the circumstances of its occurrence indicate that the deterrent is derived from the food-plant, if not identical with its poisons.

(*g*) That the great prevalence of the types of coloration commonly interpreted as " warning coloration " among the insects feeding upon these plants, and the behaviour of both the ants and the birds toward the insects having these food-plants, affords ground for the belief that in these insects warning colours and plant-derived deterrents (poisons ?) combine to make them relatively unacceptable to birds.

(*h*) That the relative unacceptability of many insects to birds must depend upon other factors, not upon plant-derived deterrents.

For their interpretation these bird-insect experiments depend upon a mathematical expression of the order of acceptance exhibited by wild birds in a state of freedom. I believe that to some degree these experiments must reflect the usual behaviour of these birds in their search for insect food; that in that search, the birds habitually concentrate their attention upon those insects which are at the time available and the more acceptable, to the partial exclusion of others which to them are relatively less acceptable; and that insect coloration has a significant place as an indicator to them of relative acceptability.

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* 1891–93, Haase, E., " Untersuchungen über die Mimikry," *Bibl. Zool. Stuttgart*, **8**.

That warning coloration as a defensive character does not provide complete protection against most enemies—that against one or several it may fail completely—does not invalidate our belief in its reality as a factor in that complexity of contacts with their environment which condition the survival of every species. As Dr. Karl Jordan has expressed it, " The main arguments against the effectiveness of protective coloration are based on a fundamental misconception. There is no absolute protection anywhere. Protection is relative like everything else. A steel helmet did not prevent soldiers from being killed, but far more would have been killed without it."

APPENDIX A.

Some Typical Bird-tray Experiments.

Experiment XIV, July 11, 1930 (Pl. XX).

40 insects of 13 species were placed upon the tray at 9.04 a.m. At the expiration of 11 minutes, all (30) of the insects of 11 species had been eaten or carried from the tray; and of the remaining 2 species, 9 of the original 10 remained upon the tray, uneaten. In this period, a grackle made 6 trips from the tray, carrying food to nearby young; a towhee made 4 visits; and each of these birds, after deliberate inspection of the remaining insects, made leisurely departure.

Insects.	Successive tabulations.	
	9.04.	9.15, uneaten.
Lepidoptera.		
ARCTIIDAE.		
Eubaphe opella, Grt.	1	
NOCTUIDAE.		
Agrotis phyllophora, Grt.	4	
Cirphis insueta, Gn.	1	
Caenurgia erechtea, Cram.	1	
Epizeuxis aemula, Hbn.	4	
NOTODONTIDAE.		
Datana sp.	2	
LIMACODIDAE.		
Lithacodes fasciola, H.S.	1	
PYRALIDAE.		
Nomophila noctuella, D. & S.	4	
Coleoptera.		
ELATERIDAE.		
2 sp. ?	4	
SCARABAEIDAE.		
Polyphylla variolosa, Hentz.	6	
Serica, sp.	2	
CERAMBYCIDAE.		
Tetraopes tetraophthalmus, Frst.	5	4
Hemiptera.		
LYGAEIDAE.		
Lygaeus kalmii, Stal.	5	5
	40	9
*Bird visits.		
Grackle	6	
Towhee	4	
	10	

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* The family, generic, and specific names of birds mentioned here and on succeeding pages may be found in the table on page 347.

Experiment IX, June 22, 1931.

49 insects of 19 species were placed upon the tray at 5.45 a.m. At the expiration of 1¼ hours, only 1 insect (the only one of its species included in the experiment) remained upon the tray uneaten. In this period, birds of 6 species made a total of 24 visits to the tray.

Insects.	Successive tabulations.						
	5.45.	6.10.	6.20.	6.27.	6.35.	6.45.	7.00, uneaten.
Lepidoptera.							
SATYRIDAE.							
Cissia eurytus, Fabr.	2	2	2	2			
NYMPHALIDAE.							
Phyciodes tharos, Dru.	2	2	2	1	1		
SPHINGIDAE.							
Paonias excaecata, A. & S.	1						
Paonias astylus, Dru.	1						
ARCTIIDAE.							
Hyphantria textor, Harr.	2	1	1				
Estigmene congrua, Wlk.	1	1	1	1			
NOCTUIDAE.							
Lycophotia lubricans, Gn.	1	1					
Polia detracta, Wlk.	7	4	4				
Acronycta sp.	1	1					
NOTODONTIDAE.							
Nadata gibbosa, A. & S.	5	2	1				
Heterocampa manteo, Dbldy.	3	2	1				
GEOMETRIDAE.							
Macaria granitata, Gn.	3	3	2	2	2		
Ectropis crepuscularia, D. & S.	2	2	2	2			
Ellopia pellucidaria, G. & R.	7	7	6	6	6	4	
Pero sp.	3	2	2	2			
LIMACODIDAE.							
Tortricidia flexuosa, Grt.	5	5	5	5	1		
MEGALOPYGIDAE.							
Lagoa crispata, Pack.	1	1	1	1			
ZYGAENIDAE.							
Malthaca dimidiata, H.S.	1	1	1	1	1	1	1
PYRALIDAE.							
Pyrausta nubilalis, Hbn.	1	1	1	1			
	49	38	32	24	11	5	1
Bird visits.							Totals.
Towhee	2	3	2	2		1	10
Song Sparrow	1	2	2	2		1*	8
Cowbird		2					2
Robin		1					1
Catbird			1	1			2
Grackle					1†		1
							24

* Inspected tray, ate no insects.

† Finally turned from insects to grain.

Experiment XIV, June 28, 1931.

66 insects of 11 species were placed upon the tray at 6.10 a.m. In the succeeding 30 minutes, 50 insects of 9 species were eaten, and 16 insects of 2 species (all of these two species included in the experiment) were left upon the tray. In this period, birds of 4 species made a total of 23 visits to the tray, the last bird visitor making a prolonged inspection of the remaining insects, but eating none.

Insects.	Successive tabulations.			
	6.10.	6.25.	6.35.	6.40, uneaten.
Coleoptera.				
Elateridae.				
Melanotus fissilis, Say.	3	3	1	
Scarabaeidae.				
Serica sp.	15	14	5	
Diplotaxis sordida, Say.	2	2		
Phyllophaga fusca, Froel.	8	2		
Phyllophaga forsteri, Burm.	6	5	1	
Phyllophaga crenulata, Froel.	2			
Polyphylla variolosa, Hentz.	10			
Cerambycidae.				
Tetraopes tetraophthalmus, Frst.	15	15	15	15
Hypermallus parallelus, Newn.	2	2	2	
Hemiptera.				
Lygaeidae.				
Lygaeus kalmii, Stal.	1	1	1	1
Orthoptera.				
Blattidae.				
Parcoblatta uhleriana, Sauss.	2	1		
	66	45	25	16
Bird visits.				Totals.
Robin	2			2
Grackle	9		1	10
Towhee		7	2	9
Song Sparrow		1	1	2
				23

Experiment XXVII, July 12, 1931 (Pl. XXI).

40 insects of 12 species were placed upon the tray at 8.55 a.m. At the expiration of 20 minutes, 17 insects of 4 species remained upon the tray uneaten; 15 of these represented the total number of 3 species which had been included in the experiment. In this period birds of 4 species made a total of 13 visits to the tray, the visitors including towhees in both adult and juvenile plumage. The last bird visiting the tray turned from the remaining insects and ate seeds and grain.

Insects.	Successive tabulations.	
	8.55.	9.15, uneaten.
Coleoptera.		
ELATERIDAE.		
Melanotus fissilis, Say. (or related sp.)	3	2
? sp.	1	
ALLECULIDAE.		
Capnochroa fuliginosa, Melsh.	2	
COCCINELLIDAE.		
Epilachna borealis, Fabr.	5	5
SCARABAEIDAE.		
Serica georgiana, Leng.	5	
Diplotaxis sordida, Say.	5	
Phyllophaga fusca, Froel.	1	
Phyllophaga forsteri, Burm.	2	
Polyphylla variolosa, Hentz.	5	
Dichelonyx elongata, Fabr.	1	
CERAMBYCIDAE.		
Tetraopes tetraophthalmus, Frst.	5	5
Hemiptera.		
LYGAEIDAE.		
Lygaeus kalmii, Stal.	5	5
	40	17
Bird visits.		
Robin	4	
Song Sparrow	1	
Catbird	5	
Towhee	3	
	13	

Experiment XXIX, July 14, 1931 (Pl. XXII).

55 insects of 14 species were placed upon the tray at 1.55 p.m., and the experiment was terminated at 4.50 p.m. In that period, all of 9 species of insects (37) were taken from the tray, and *none* of 5 species, numbering 18, were taken. The visiting birds were of 4 species, and the last visitor, a song sparrow, turned from the remaining insects to seeds and grain.

Insects.	Successive tabulations.								
	1.55.	3.00.	3.15.	3.40.	4.00.	4.20.	4.30.	4.45.	4.50, uneaten.
Coleoptera.									
Lampyridae.									
Photinus consanguineus, Lec.	2	2	2	2	2	2	2	2	2
Photuris pennsylvanica, DeG.	1	1	1	1	1				
Cantharidae.									
Cantharis rotundicollis, Say.	1	1	1	1	1	1			
Elateridae.									
? sp.	5	5	5	5	5	4	4		
Alleculidae.									
Capnochroa fuliginosa, Melsh.	6	6	6	4	4	4	3	1	
Coccinellidae.									
Epilachna borealis, Fabr.	5	5	5	5	5	5	5	5	5
Scarabaeidae.									
Serica georgiana, Leng.	6	6	3	2	2	1			
Diplotaxis sordida, Say.	6	6	6	5	5	4	2		
Polyphylla variolosa, Hentz.	10	7	3	1					
Dichelonyx elongata, Fabr.	1	1							
Cerambycidae.									
Judolia cordifera, Oliv.	1	1	1	1	1				
Tetraopes tetraophthalmus, Frst.	5	5	5	5	5	5	5	5	5
Chrysomelidae.									
Chrysochus auratus, Fabr.	3	3	3	3	3	3	3	3	3
Hemiptera.									
Lygaeidae.									
Lygaeus kalmii, Stal.	3	3	3	3	3	3	3	3	3
	55	52	44	38	37	32	27	19	18
Bird visits.									Totals.
Robin	3	3		1		1			8
Song Sparrow		3			1		1	1	6
Catbird			2		2	1		2	7
Towhee				1		1			2
									23

Experiment XLI, July 28, 1931 (Pl. XXII).

36 insects of 17 species were placed upon the tray at 10 a.m. At the expiration of 1¾ hours, 13 insects of 5 species remained upon the tray, and of these 5 species only 1 insect had been taken; while all the insects of the remaining 12 species had been eaten by the visiting birds. Birds of 4 species made a total of 22 visits to the tray, the last visitor not taking any food.

Insects.	Successive tabulations.				
	10.00.	10.30.	10.45.	11.15.	11.45 uneaten.
Coleoptera.					
Carabidae.					
Harpalus pennsylvanicus, Dej.	1	1	1	1	
Lycidae.					
Calopteron reticulatum, Fabr.	4	3	3	3	3
Elateridae.					
Melanotus sp. (or related)	1				
Alleculidae.					
Capnochroa fuliginosa, Melsh.	2	1			
Scarabaeidae.					
Serica georgiana, Leng.	2	1			
Serica sp.	1				
Diplotaxis sordida, Say.	2	2	2		
Phyllophaga fusca, Froel.	1				
Phyllophaga forsteri, Burm.	1				
Phyllophaga crenulata, Froel.	1				
Phyllophaga gracilis, Burm.	6				
Polyphylla variolosa, Hentz.	3				
Cerambycidae.					
Tetraopes tetraophthalmus, Frst.	4	4	4	4	4
Chrysomelidae.					
Chrysochus auratus, Fabr.	4	4	4	4	4
Curculionidae.					
Brachyrhinus sulcatus, Fabr.	1	1	1	1	1
Hemiptera.					
Lygaeidae.					
Lygaeus kalmii, Stal.	1	1	1	1	1
Hymenoptera.					
Ichneumonidae.					
Ophion sp. (or related)	1				
	36	18	16	14	13
Bird visits.					Totals.
Song Sparrow	8	2	2	1	13
Catbird	2		3	1	6
Robin		1		1	2
Towhee			1		1
					22

Experiment XLIII, August 2, 1931.

62 insects of 18 species were placed upon the tray at 8 a.m. At the expiration of 1½ hours, all the insects (52) of 16 species had been eaten; *none* of the insects (10) of the remaining 2 species had been taken from the tray. In this period, birds of 3 species made a total of 25 visits to the tray.

Insects.	Successive tabulations.			
	8.00.	8.20.	9.00.	9.30, uneaten.
Lepidoptera.				
NOCTUIDAE.				
Rhodophora florida, Gn.	3	3	1	
Sidemia devastator, Brace	10	3		
Autographa simplex, Gn.	2	1		
Autographa precationis, Gn.	1			
Caenurgia erechtea, Cram.	10	7		
Plathypena scabra, Fabr.	9	7	1	
GEOMETRIDAE.				
Pero sp.	4	3		
Apicia confusaria, Hbn.	1	1		
LIMACODIDAE.				
Prolimacodes badia, Hbn.	1	1		
Coleoptera.				
CARABIDAE.				
Harpalus pennsylvanicus, Dej.	1	1	1	
LYCIDAE.				
Calopteron reticulatum, Fabr.	5	5	5	5
MELOIDAE.				
Epicauta marginata, Fabr.	5	5	5	5
ELATERIDAE.				
Melanotus sp. (or related)	3	2	2	
TENEBRIONIDAE.				
Tenebrio obscurus, Fabr.	1	1		
SCARABAEIDAE.				
Serica sp.	1	1		
Diplotaxis sordida, Say.	1	1	1	
Phyllophaga gracilis, Burm.	3	3		
Polyphylla variolosa, Hentz	1			
	62	45	16	10
Bird visits.				Totals.
Towhee	6	6	2	14
Song Sparrow		6	3	9
Grackle		2		2
				25

Experiment XLIV, August 4, 1931 (Pl. XXIII).

67 insects of 29 species were placed upon the tray at 5 p.m. At 7.15 p.m., 61 of these, belonging to 26 species, had been taken from the tray by the birds, and there then remained only 6 insects of 4 species, 5 of these remaining insects being the only representatives of their species included in the experiment at its inception. In the stated period, birds of 4 species made a total of 52 visits to the tray.

Insects.	Successive tabulations.						
	5.00.	5.15.	5.45.	6.15.	6.30.	7.00.	7.15, uneaten.
Lepidoptera.							
Papilionidae.							
Papilio glaucus, L.	1	1	1	1			
Danaidae.							
Danaida archippus, Fabr.	2	2	1	1	1	1	1
Nymphalidae.							
Vanessa virginiensis, Dru.	5	5	4	3			
Vanessa cardui, L.	5	5	4	2			
Hesperiidae.							
Epargyreus tityrus, Fabr.	3	2	1	1			
Sphingidae.							
Smerinthus geminatus, Say.	1						
Paonias excaecata, A. & S.	4	3					
Ampeloeca myron, Cram.	2	1					
Syntomidae.							
Scepsis fulvicollis, Hbn.	2	2	2	2	2	2	2
Lithosiinae.							
Hypoprepia miniata, Kby.	2	2	2	2	2	2	2
Arctiinae.							
Eubaphe aurantiaca, Hbn.	1	1	1	1	1	1	1
Isia isabella, A. & S.	1						
Noctuidae.							
Rhodophora florida, Gn.	1	1	1	1	1		
Polia renigera, Steph.	7	6	1	1			
Septis arctica, Bdv.	1						
Sidemia devastator, Brace.	5						
Apamea nictitans, L.	1	1	1	1			
Euthisanotia grata, Fabr.	2	2	2	2	1	1	
Caenurgia erechtea, Cram.	5	3	3	2	2		
Autographa biloba, Steph.	1						
Notodontidae.							
Datana sp.	1						
Nadata gibbosa, A. & S.	1	1					
Ianassa lignicolor, Wlk.	1	1					
Schizura unicornis, A. & S.	2	2	1	1	1		
Geometridae.							
Lygris diversilineata, Hbn.	2	2	2	1	1	1	
Metanema quercivoraria, Gn.	1	1	1	1	1		
Pero sp.	5	4	3	3	1		
Limacodidae.							
Prolimacodes badia, Hbn.	1						
Pyralidae.							
Desmia funeralis, Hbn.	1	1	1	1	1		
	67	49	32	27	15	8	6
Bird visits.							Totals.
Towhee	6	5	4	8	2	1	26
Song Sparrow	5	7	2	5	3		22
Robin		3					3
Catbird			1				1
							52

APPENDIX B.

Explanation of the Derivation of Acceptability Ratings.

(See pages 349 and 350.)

In an experiment involving 48 insects, with 12 of them eaten by the birds before the 2nd tabulation of the contents of the tray (each of these 12 consequently receiving a rating of acceptability 100) and 6 left upon the tray at the termination of the experiment (each of these 6 therefore being rated 0), there remain 30 insects to be assigned ratings spaced between 100 and 0, according to the order of their acceptance. In that order, beginning with the first of the 30 to be eaten, their acceptability ratings would be thus :—

96·7, 93·5, 90·3, 87·0, 83·8, 80·6, and so on, until the last to be taken, the 30th, would receive a rating of 3·2.

We do not know the exact order in which these 30 insects were taken from the tray; but if 5 of them were taken between the 2nd and the 3rd tabulations, then the ratings of these 5 must have been 96·7, 93·5, 90·3, 87·0, 83·8. Not knowing which of these 5 was taken first, we assign to each of them the *rating of the median insect of the series,* 90·3, which expresses its true rating (for this experiment) with as small a margin of possible error as the conditions of experiment permit. Then by assembling all of these single-experiment ratings for each species and averaging them, we obtain an average acceptability rating which impartially expresses the results of all the experiments for each of the insect species involved. Of necessity, the value of that figure as a measure of the relative acceptability of any insect species largely depends upon the fairness of its competition with other insects and upon the number of times it was used in the whole series of experiments.

APPENDIX C: ACCEPTABILITY RATINGS OF INSECTS.

Name.	Experiments.	Insects on tray.	Of this species.	Acceptability.	Bird visitors.*
Section I: Those with Ratings 60–100					
Lepidoptera.					
SPHINGIDAE.					
Lapara bombycoides, Wlk.	13	699	20	88·1	*1*, 2, *3*, 4, 5, 7, 9
Smerinthus geminatus, Say.	3	227	3	100·0	1, 2, 5, *7*
Paonias excaecata, A. & S.	22	1304	49	93·0	1, 2, *3*, 4, *5*, *7*, 10
Paonias myops, A. & S.	7	381	9	99·2	*1*, 2, 4, 5, 7, 10
Paonias astylus, Dru.	7	389	7	96·5	1, 2, 3, *5*, 7
Ampeloeca myron, Cram.	2	133	3	93·6	1, 2, 5, 7
Darapsa pholus, Cram.	4	249	4	98·5	*1*, 2, 3, 5, 7
SATURNIIDAE.					
Telea polyphemus, Cram.	3	212	3	80·3	*1*, 2, 3, 5, 7
Automeris io, Fabr.	9	529	11	82·7	1, *2*, 3, *4*, 5, 6, 7
ARCTIIDAE.					
Halisidota caryae, Harr.	10	662	29	71·2	1, *2*, 4, *5*, *7*, 11
Halisidota tessellaris, A. & S.	17	1028	50	62·9	*1*, 2, *3*, 4, *5*, 6, 7
Diacrisia virginica, Fabr.	5	307	5	71·4	1, 2, *3*, 4, 5, 8
Isia isabella, A. & S.	6	409	7	93·4	1, 2, 4, 5, 7
Ecpantheria deflorata, Fabr.	3	186	3	94·6	1, 2, 4, *5*, 7
Apantesis nais, Dru. and *vittata*, Fabr.	12	672	25	68·8	*1*, *2*, 3, *4*, *5*, 7, 8, 11
NOCTUIDAE.					
Lygranthoecia marginata, Haw.	3	219	4	64·2	1, 2, 3, 8, 9
Schinia arcigera, Gn.	1	69	2	72·5	*2*, 3, 8, 9
Feltia ducens, Wlk.	19	999	124	71·0	*1*, *2*, *3*, 4, 5, 6, 7, 8, 9
Agrotis ypsilon, Rott.	3	113	11	86·9	*1*, 2, 3
Agrotis phyllophora, Grt.	4	189	13	88·8	1, 2, 3, 5, 7, 8
Matuta elimata, Gn.	11	611	33	89·9	*1*, 2, *3*, 4, 5, 6, 7
Polia detracta, Wlk.	3	169	12	90·6	1, 2, 3, 4, 5, 7, 9
Polia renigera, Steph.	13	722	30	71·8	*1*, 2, 3, 4, *5*, *6*, 7, 8, 9
Cirphis & *Leucania* sp.	31	1698	94	78·1	*1*, *2*, *3*, 4, 5, *6*, 7, 8
Oncocnemis riparia, Morr.	2	172	5	70·4	1, 2, 5, *7*
Septis arctica, Bdv.	15	940	23	89·9	1, *2*, 3, 4, *5*, *7*, 8
Sidemia devastator, Br.	27	1443	148	86·8	*1*, *2*, *3*, 4, 5, 6, *7*, 8, 9, 10
Acronycta sp.	8	538	10	67·0	1, 2, *3*, 4, *5*, 7, 8
Catocala (4 sp.)	5	223	6	84·6	*1*, 2, *3*, 5, 7, 8
Euparthenos nubilis, Hbn.	5	338	5	96·0	1, 2, 4, 5, 7
Caenurgia erechtea, Cram.	21	1103	62	63·8	*1*, 2, *3*, 4, 5, 7, 9, 10
Argyrostrotis anilis, Dru.	10	580	10	61·4	*1*, 2, *3*, 4, 5, 7
Autographa simplex, Gn.	6	371	11	77·0	1, 2, 4, 5, 7
Autographa brassicae, Riley	3	222	5	72·8	*1*, 2, 3, 4, 5
Autographa precationis, Gn.	2	114	5	71·2	*1*, 2, 4
Scoliopteryx libatrix, L.	1	18	1	80·0	*1*
Panopoda rufimargo, Hbn.	4	236	6	93·5	*1*, 2, 3, *5*
Plathypena scabra, Fabr.	5	303	24	63·8	*1*, 2, 4, 5
Dull-coloured Noctuids, 10 sp.	15	859	22	86·3	*1*, 2, *3*, 4, *5*, 7

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* The numerals in this column represent bird species, in correspondence with the numbered list on page 347. A number in italics indicates that in one or more experiments it was possible to identify this bird as having accepted this insect; but the absence of italics does not indicate that the birds thus designated may not have done so.

Name.	Experiments.	Insects on tray.	Of this species.	Acceptability.	Bird visitors.*
Lepidoptera.					
NOTODONTIDAE.					
Ichthyura inclusa, Hbn.	2	119	2	92·0	1, 2, 4, 5, 7
Datana sp.	36	1878	93	86·5	*1*, *2*, *3*, 4, *5*, 7, 8, 10
Lophodonta angulosa, A. & S.	13	777	27	79·0	*1*, 2, *3*, 4, 5, 6, 7, 8, 9
Nadata gibbosa, A. & S.	32	1744	93	74·7	*1*, *2*, *3*, 4, *5*, 7, 8, 9, 10
Symmerista albifrons, A. & S.	27	1378	51	76·2	*1*, *2*, *3*, 4, *5*, *6*, 7
Heterocampa umbrata, Wlk.	7	438	13	95·9	1, 2, *3*, 4, 5, 7, 8
Heterocampa manteo, Dbldy.	6	342	9	75·2	1, 2, 4, 5, 7, 8
Ianassa lignicolor, Wlk.	9	558	12	82·4	1, 2, 4, *5*, 7
Fentonia marthesia, Cram.	3	146	9	84·9	1, 2, 4, 5, 7, 8
Dull-coloured Notodontids (2 sp.)	2	80	2	68·5	1, 2, 3
LYMANTRIIDAE.					
Olene sp.	16	861	56	85·1	*1*, *2*, *3*, 4, *5*, 6, 7, 8
EUPTEROTIDAE.					
Apatelodes torrefacta, A. & S.	17	918	23	86·0	*1*, 2, *3*, 4, *5*, 7
LASIOCAMPIDAE.					
Malacosoma americana, Fabr.	22	1179	146	75·3	*1*, *2*, *3*, *4*, *5*, *6*, *7*, 8, 9
GEOMETRIDAE.					
Dyspteris abortivaria, H.S.	1	69	1	100·0	2, 3, 8, 9
Eudule mendica, Wlk.	2	100	4	62·7	1, 2, 5, 7
Paraphia subatomaria, Wood	4	234	5	77·2	1, 2, 4, 5, 7, 8
Amphidasis cognataria, Gn.	2	130	2	78·0	1, 2, 4, 5, 8
Gonodontis hypochraria, H.S.	7	368	9	64·2	1, 2, 4, 5, 7, 8
Pero sp.	22	1304	47	67·0	*1*, 2, *3*, 4, *5*, 6, 7, 8
Apicia irraria, B. & McD.	6	386	10	83·5	1, 2, 4, 5, 7, 8
Sabulodes transversata, Dru.	16	832	42	75·1	*1*, *2*, *3*, 4, 5, 6, 8, 9
LIMACODIDAE.					
Prolimacodes badia, Hbn.	5	351	5	81·0	*1*, 2, 4, 5, 7
TORTRICIDAE.					
Cacoecia conflictana, Wlk.	2	72	5	71·6	2, 4, 5, 7, 8
Coleoptera.					
TENEBRIONIDAE.					
Tenebrio obscurus, Fabr.	2	125	2	79·0	1, 2, 4
SCARABAEIDAE.					
Serica sericea, Ill.	11	715	21	69·4	2, 3, 4, 5, 7, 8, 9
Diplotaxis sordida, Say.	33	2108	107	61·5	*1*, 2, *3*, 4, *5*, 6, 7, 8, 9
Phyllophaga gracilis, Burm.	9	559	27	80·6	1, 2, 3, 4, 5, 7, 8
Phyllophaga fusca, Froel.	12	823	67	88·1	1, 2, 3, 4, 5, 7
Phyllophaga forsteri, Burm.	27	1677	138	80·0	1, *2*, 3, 4, *5*, 7, 8, 9, 10
Phyllophaga crenulata, Froel.	18	1210	75	77·7	*1*, *2*, 4, 5, 6, *7*
"May beetles" (*Phyllophaga* & *Polyphylla* sp.).	22	978	139	89·7	*1*, *3*, 4, *5*, *6*
Polyphylla variolosa, Hentz	21	1223	135	92·6	1, *2*, *3*, 4, 5, *7*, 8, 9, 10
Dichelonyx elongata, Fabr.	25	1503	125	60·4	*1*, *2*, *3*, 4, 5, *6*, *7*, 8, 11
Ligyrodes relictus, Say.	9	527	13	90·1	*1*, 2, 3, 8, 9
Section II: Those with Ratings 25–60.					
Lepidoptera.					
CERATOCAMPIDAE.					
Anisota stigma, Fabr.	9	618	14	41·3	1, 2, 3, 4, 5, 7, 9
Anisota rubicunda, Fabr.	6	325	7	36·1	*1*, *2*, 3, 5, 7

* See note p. 381.

Name.	Experiments.	Insects on tray.	Of this species.	Acceptability.	Bird visitors.*
Lepidoptera.					
Arctiidae.					
Eubaphe opella, Grt.	28	1500	121	38·1	*1*, *2*, *3*, 4, 5, *6*, 7, 8, 9, 10
Phragmatobia fuliginosa, L.	2	109	2	32·5	1, 2, 5, 7
Hyphantria cunea, Dru.	11	554	16	51·1	*1*, 2, *3*, 4, *5*, 6, *7*, 8
Estigmene congrua, Wlk.	3	163	3	51·6	1, 2, 4, 5, 7
Apantesis intermedia, Str.	2	77	4	39·7	1, 2, 4
Apantesis arge, Dru.	3	154	3	46·3	*1*, 2, 3, 4, *6*
Euchaetias egle, Dru.	5	208	5	36·6	1, 2, *3*, 4, 5, *6*, 7 ,8
Utetheisa bella, L.	3	127	3	25·0	*1*, 2, 3
Noctuidae.					
Rhodophora florida, Gn.	9	472	11	31·7	*1*, 2, 3, 4, 5, *6*, 7
Lygranthoecia brevis, Grt.	2	88	4	51·0	*1*, 2
Schinia nundina, Dru.	2	102	3	27·3	1, 2, 3, 5, 8
Polia meditata, Grt.	3	138	13	53·2	*1*, 2, 3
Callopistria monetifera, Gn.	1	45	1	36·0	1, 2, 5, 7
Apamea nictitans, L.	18	971	35	52·0	*1*, *2*, *3*, 4, 5, 7, 8, 9, 10
Derrima stellata, Wlk.	5	323	6	25·1	*1*, 2, 3, 4, 5, *8*, 9
Euthisanotia grata, Fabr.	8	510	12	36·8	1, 2, 3, 4, 5, 7, 10
Chamyris cerintha, Tr.	2	132	3	51·6	1, 2, 5, 7
Epizeuxis lubricalis, Geyer.	5	276	5	47·4	1, 2, 3, 5, 8
Small dull Noctuids (3 sp.)	3	153	6	49·5	1, 2, 4, 5, 7
Notodontidae.					
Schizura, 2 sp.	2	117	3	42·3	1, 2, 5, 7
Cerura borealis, Bdv.	1	87	3	57·3	1, *3*
Lymantriidae.					
Euproctis chrysorrhoea, L.	1	18	1	50·0	*1*, 3
Stilpnotia salicis, L.	1	61	3	57·3	1, 2, 5, 9
Lasiocampidae.					
Malacosoma disstria, Hbn.	4	249	13	51·0	*1*, 2, 4, *5*, 7
Geometridae.					
Synchlora aerata, Fabr.	1	66	1	54·0	4, 5, 8
Dichorda iridaria, Gn.	4	183	4	39·2	*1*, 2, *3*
Calocalpe undulata, L.	2	120	3	29·3	1, *3*
Lygris diversilineata, Hbn.	8	507	25	43·8	*1*, 2, *3*, 4, 5, 7, 8, 9
Caripeta piniata, Pack.	7	432	12	47·1	*1*, 2, *3*, 4, 5, 7, 11
Ellopia pellucidaria, G. & R.	13	791	37	40·5	*1*, 2, 3, 4, 5, 7, 8, 11
Euchlaena serrata, Dru.	14	862	32	34·2	*1*, 2, 3, 4, *5*, 7
Euchlaena johnsonaria, Ftch.	12	746	32	53·8	1, 2, 3, 4, 5, 7, 8
Metanema quercivoraria, Gn.	3	177	7	39·5	1, 2, 3, 4, 5, 7
Apicia confusaria, Hbn.	14	852	43	33·0	*1*, 2, 3, 4, *5*, 7, 10
Tetracis crocallata, Gn.	1	41	2	35·0	1, 2, 4, 5
Sabulodes lorata, Grt.	3	186	4	59·7	1, 2, 4, 5, 7
Small dull Geometrids, 4 sp.	6	280	12	45·1	1, 2, 3, 4, 5, 7, 8
Limacodidae.					
Tortricidia flexuosa, Grt.	8	407	49	41·3	*1*, 2, *3*, *4*, 5, 6, 7, 8, 9
Small Limacodids, 2 sp.	2	112	2	50·0	1, 2, 4, 5, 7
Megalopygidae.					
Lagoa crispata, Pack.	13	834	29	55·5	1, *2*, 4, *5*, 7, 8, 9
Pyralidae.					
Desmia funeralis, Hbn.	4	220	4	36·8	*1*, 2, *3*, 5, 6, 7
Nomophila noctuella, D. & S.	28	1669	185	52·2	*1*, *2*, *3*, *4*, *5*, 7, 8, 9, 10
Pyrausta nubilalis, Hbn.	6	344	7	28·7	*1*, *2*, 3, 4, 5, 7, 8
Tortricidae.					
Eulia alisellana, Rob.	2	113	15	37·0	4, 5, 7, 8

* See note p. 381.

Name.	Experiments.	Insects on tray.	Of this species.	Acceptability.	Bird visitors.*
Coleoptera.					
CARABIDAE.					
Harpalus pennsylvanicus, Say.	20	1272	76	51·6	*1*, 2, *3*, 4, 5, *6*, *7*, 8, 9, 10
Small dark Carabids (?4 sp.)	1	103	37	26·3	*1*, 4
SILPHIDAE.					
Silpha surinamensis, Fabr.	3	187	5	40·0	1, 2, 3, 4, 5, 7, 10
CANTHARIDAE.					
Cantharis rotundicollis, Say.	5	295	8	25·3	*1*, 2, *3*, 5, 7, 9
Cantharis sp.	5	418	10	44·2	*1*, 2, 4, 5, 7, 8
ELATERIDAE.					
Melanotus fissilis, Say, & similar sp.	37	2123	103	53·1	*1*, *2*, *3*, 4, *5*, *6*, 7, 9
ALLECULIDAE.					
Capnochroa fuliginosa, Melsh.	8	438	30	33·8	*1*, *2*, 3, 5, *6*, *7*, 8
SCARABAEIDAE.					
Serica georgiana, Leng.	27	1770	207	56·3	*1*, *2*, 3, 4, *5*, 7, 8, 9, 11
Macrodactylus subspinosus, Fabr.	5	380	47	26·2	1, *2*, 4, 5, 7, 8
CERAMBYCIDAE.					
Derobrachus brunneus, Frst.	2	110	2	29·5	1, 2, 5, *6*, 7
Hypermallus parallelus, Newn.	3	237	5	48·2	1, 2, 4, 5, 7
Judolia cordifera, Oliv.	2	102	2	38·5	1, 2, 4, 5, 7
Cyllene robiniae, Frst.	3	164	13	30·7	*1*, 2, 3
CURCULIONIDAE.					
Brachyrhinus sulcatus, Fabr.	3	182	4	36·7	1, 2, 4, 5, 7
Hemiptera.					
PENTATOMIDAE.					
Acrosternum hilare, Say.	2	127	5	35·6	1, 2, 5, 7
Section III: Those with Ratings 0–25.					
Lepidoptera.					
SATURNIIDAE.					
Tropaea luna, L.	1	81	1	12·0	1, 2, 3, 5, 7
SYNTOMIDAE.					
Scepsis fulvicollis, Hbn.	8	467	13	3·8	1, 2, 3, 4, 5, 7, 8, 9
Lycomorpha pholus, Dru.	1	62	1	0·0	1, 2, 3, 8
LITHOSIINAE.					
Hypoprepia miniata, Kby.	9	545	10	8·1	1, 2, 3, 4, 5, 7
ARCTIINAE.					
Ammalo tenera, Hbn.	1	104	1	7·0	?
Eubaphe aurantiaca, Hbn.	14	898	25	14·0	1, 2, 3, 4, 5, 7, 8, 9, 10
NOCTUIDAE.					
Callopistria mollissima, Gn.	1	69	1	21·0	2, 3, 8, 9
GEOMETRIDAE.					
Haematopis grataria, Fabr.	2	133	2	8·5	1, 2, 3, 5, 7, 10
Eulype hastata, L.	1	55	1	18·0	1, 2, 3, 5
ZYGAENIDAE.					
Malthaca dimidiata, H.S.	3	162	5	10·8	1, 2, 3, 5, 8
AEGERIIDAE.					
Synanthedon sigmoidea, Beut.	4	195	19	8·4	1, 2, 3, 4, 8
YPONOMEUTIDAE.					
Atteva aurea, Fitch	1	59	1	0·0	1, 2, 3, 8

* See note p. 381.

Name.	Experiments.	Insects on tray.	Of this species.	Acceptability.	Bird visitors.*
Coleoptera.					
CARABIDAE.					
Harpalus caliginosus, Fabr.	1	42	1	0·0	1, 2, 3, 4, 5, 7
SILPHIDAE.					
Necrophorus americanus, Oliv.	2	123	2	0·0	1, 2, 3, 4, 5, 7
Necrophorus orbicollis, Say.	3	171	3	0·0	1, 2, 3, 4, 5, 7, 8
Necrophorus pustulatus, Hrsh.	2	123	2	0·0	1, 2, 3, 4, 5, 7
LYCIDAE.					
Calopteron reticulatum, Fabr.	9	519	47	7·3	1, 2, *3*, 4, 5, 6, 7
LAMPYRIDAE.					
Photinus consanguinius, Lec.	3	157	7	0·0	?
Photuris pennsylvanica, DeG.	9	535	9	12·7	1, 2, 3, 4, 5, 6, 7, 9
CANTHARIDAE.					
Chauliognathus pennsylvanicus, DeG.	1	62	5	0·0	1, 2, 3
OEDEMERIDAE.					
Nacerda melanura, L.	1	48	1	0·0	1, 2, 4, 5, 8
MELOIDAE.					
Epicauta marginata, Fabr.	7	363	50	3·0	*1*, 2, *3*, 4, 5, 6, 7
Epicauta pennsylvanica, DeG.	1	50	1	0·0	1, 2, 3
COCCINELLIDAE.					
Epilachna borealis, Fabr.	3	143	20	0·0	1, 2, 4, 5, 7, 8
SCARABAEIDAE.					
Trox unistriatus, Beauv.	3	192	3	4·0	1, 2, 3, 4, 5, 7, 8, 9, 10
CERAMBYCIDAE.					
Tetraopes tetraophthalmus, Frst.	13	680	95	3·1	1, 2, 3, 4, 5, 6, 7, 8, 10
CHRYSOMELIDAE.					
Crioceris duodecimpunctata, L.	2	200	29	3·0	1, 2, 4, 5
Labidomera clivicollis, Kby.	4	220	14	1·3	1, 2, 3, 5, 7, *10*
Chrysochus auratus, Fabr.	4	208	22	0·0	1, 2, 5, 7
Trirhabda canadensis, Kby.	1	56	5	0·0	2, 5, 7
Hemiptera.					
LYGAEIDAE.					
Lygaeus kalmii, Stal.	9	482	27	0·0	1, 2, 3, 4, 5, 7
Neuroptera.					
CHRYSOPIDAE.					
Chrysopa sp.	16	794	48	14·9	1, 2, *3*, 4, *5*, *6*, 8
Hymenoptera.					
ICHNEUMONIDAE.					
Ophion sp. (or related)	10	538	20	9·8	*1*, 2, *3*, 4, 5, 7, 8
VESPIDAE.					
Polistes pallipes, Lep.	5	280	9	25·0	*1*, 2, 3, 4, 5, 8
Vespa diabolica, Sauss.	5	283	14	5·0	*1*, 2, 3, 4, 5, 8
Vespa maculata, L.	2	84	2	25·0	1, 2, 3, 4, 8
BOMBIDAE.					
Bombus sp.	1	85	10	0·0	1, 3, 5
APIDAE.					
Apis mellifica, L.	1	85	10	1·6	1, 3, 5

* See note p. 381.

PLATE XVIII.

Ant-refused insects having related and poisonous food-plants.

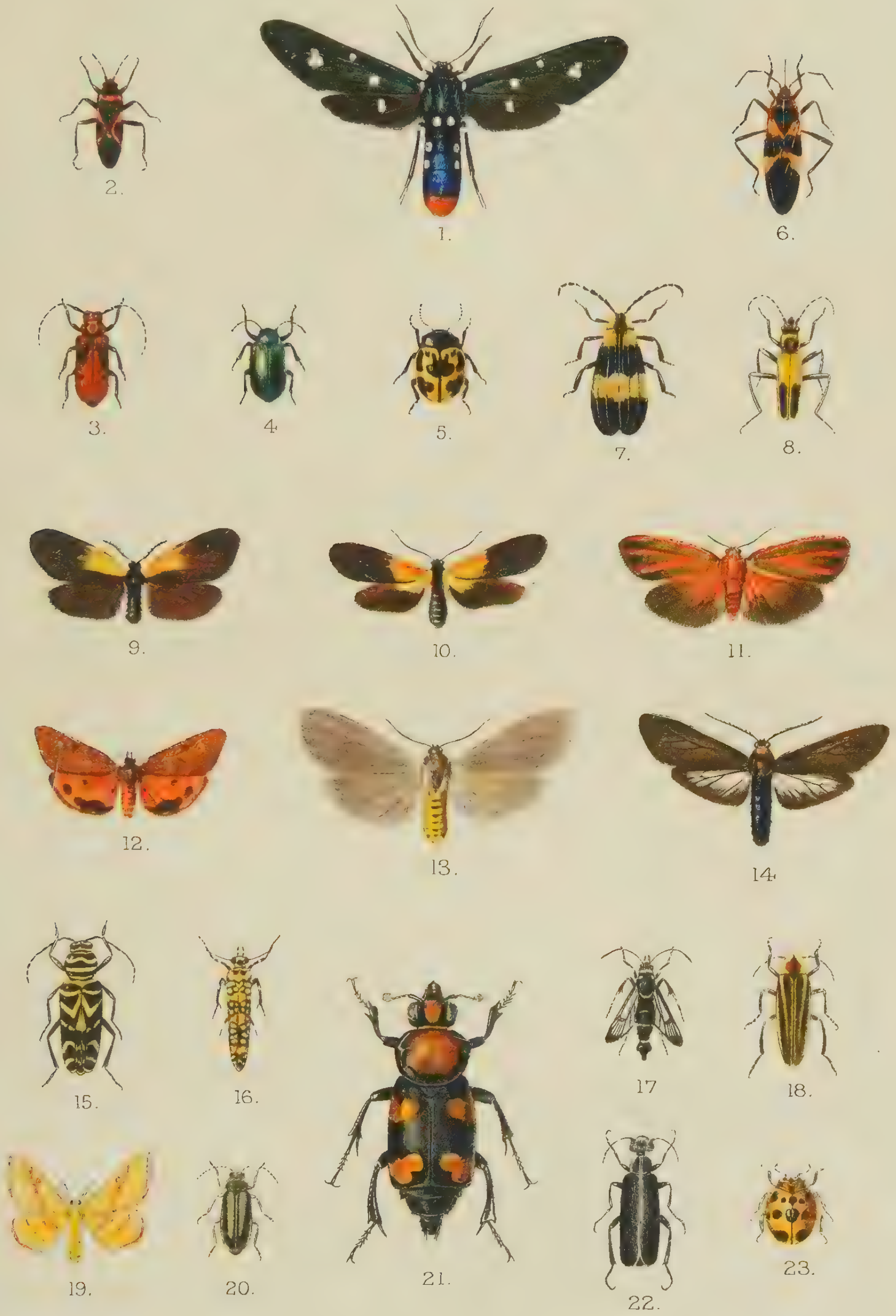
Fig.		Food-plant.	Relative acceptability to birds.
1.	*Syntomeida epilais*, Walk. (SYNTOMIDAE)	*Nerium*	Not tested
2.	*Lygaeus kalmii*, Stal. (LYGAEIDAE)	*Asclepias*	0·0
3.	*Tetraopes tetraophthalmus*, Frst. (CERAMBYCIDAE)	*Asclepias*	3·1
4.	*Chrysochus auratus*, Fabr. (CHRYSOMELIDAE)	*Apocynum*	0·0
5.	*Labidomera clivicollis*, Kby. (CHRYSOMELIDAE)	*Asclepias*	1·3

Similar in food-plant and coloration but not available for test.

6.	*Oncopeltus fasciatus*, Dall. (LYGAEIDAE)	*Asclepias*	Not tested

Ant-accepted insects of low relative acceptability to birds.

7.	*Calopteron reticulatum*, Fabr. (LYCIDAE)	—	7·3
8.	*Chauliognathus pennsylvanicus*, De G. (CANTHARIDAE)	—	0·0
9.	*Malthaca dimidiata*, H.S. (ZYGAENIDAE)	—	10·8
10.	*Lycomorpha pholus*, Dru. (SYNTOMIDAE)	—	0·0
11.	*Hypoprepia miniata*, Kby. (LITHOSIINAE)	—	8·1
12.	*Eubaphe aurantiaca*, Hbn. (ARCTIINAE)	—	14·0
13.	*Euchaetias egle*, Dru. (ARCTIINAE)	—	36·6
14.	*Scepsis fulvicollis*, Hbn. (SYNTOMIDAE)	—	3·8
15.	*Cyllene robiniae*, Frst. (CERAMBYCIDAE)	—	30·7
16.	*Atteva aurea*, Fitch (YPONOMEUTIDAE)	—	0·0
17.	*Synanthedon sigmoidea*, Beut. (AEGERIIDAE)	—	8·4
18.	*Photuris pennsylvanica*, De G. (LAMPYRIDAE)	—	12·7
19.	*Haematopis grataria*, Fabr. (GEOMETRIDAE)	—	8·5
20.	*Trirhabda canadensis*, Kby. (CHRYSOMELIDAE)	—	0·0
21.	*Necrophorus americanus*, Oliv. (SILPHIDAE)	—	0·0
22.	*Epicauta marginata*, Fabr. (MELOIDAE)	—	3·0
23.	*Epilachna borealis*, Fabr. (COCCINELLIDAE)	—	0·0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INSECTS REFUSED OR ACCEPTED BY ANTS.

1.

2.

3.

4.

5.

The feeding tray and some of its visitors.

PLATE XIX.

The feeding tray and some of its visitors.

FIG. 1. The tray in position.
2. The Blue Jay *Cyanocitta cristata* (CORVIDAE).
3. The Brown Thrasher *Toxostoma rufum* (MIMIDAE).
4. The Grackle *Quiscalus quiscula* (ICTERIDAE).
5. American Robin *Turdus migratorius* (TURDIDAE) left, and Song Sparrow *Melospiza melodia* (FRINGILLIDAE) right.

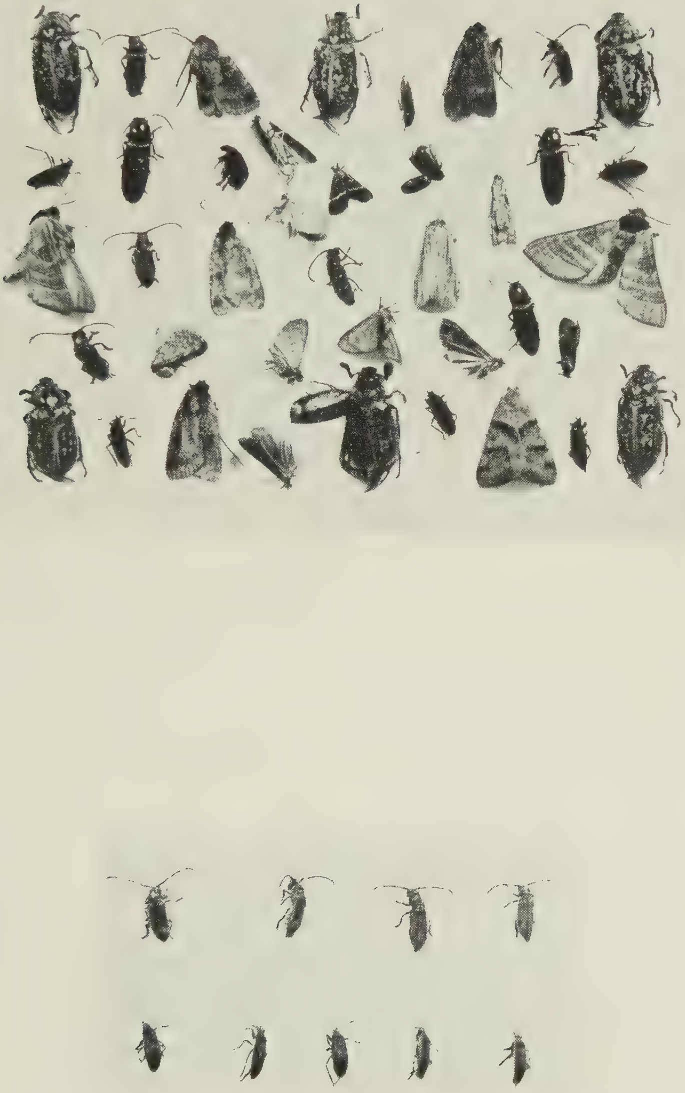
PLATE XX.

Bird-tray Experiment XIV, July 11, 1930.

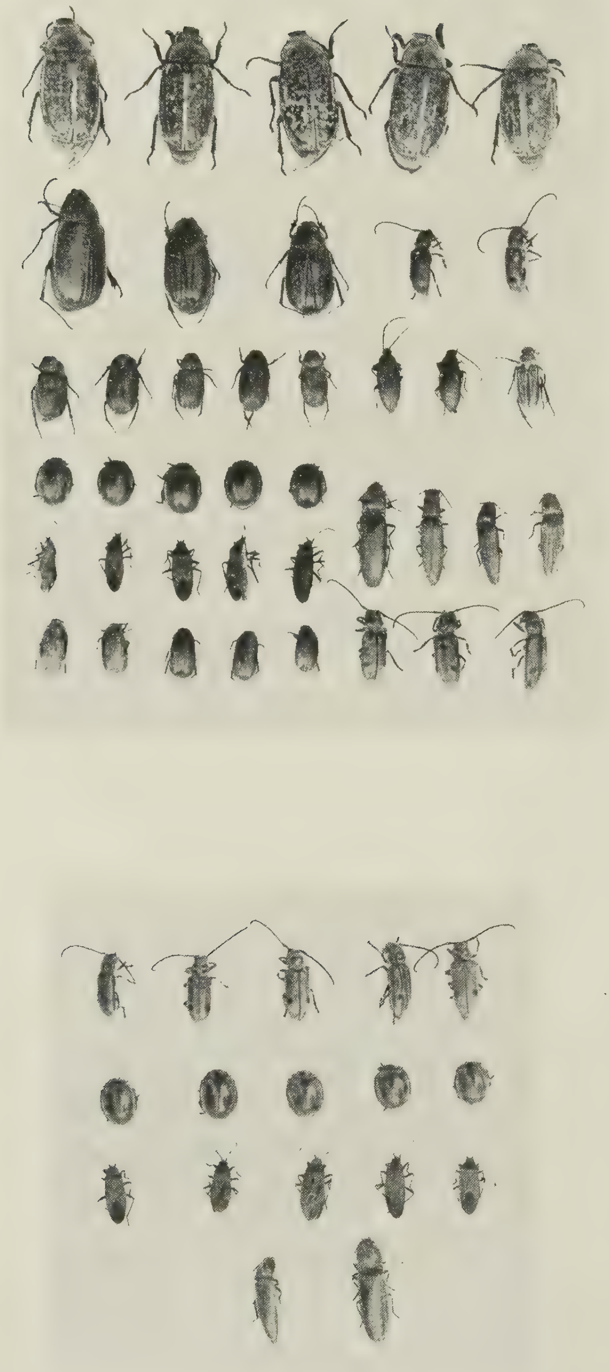
Above. The tray at commencement of experiment containing 40 insects of 13 species.

Below. At the termination of the experiment, 9 insects of 2 species remained upon the tray. Of these 2 species (*Tetraopes tetraophthalmus* and *Lygaeus kalmii*), only 1 insect (*Tetraopes*) had been eaten, while all the other insects (30, of 11 species) had been taken by grackles and towhees in 11 minutes and in a total of 10 visits to the tray.

Plate XX.



Bird tray experiment XIV.



Bird tray experiment XXVII.

Plate XXI.

Bird-tray Experiment XXVII.

Above. The 40 insects of 12 species offered at the commencement of the experiment.

Below. At the termination of the experiment, 17 insects of 4 species remained on the tray. These included 5 each of *Tetraopes tetraophthalmus*, Frst., *Epilachna borealis*, F., and *Lygaeus kalmii*, Stal., being all the examples of these species that were included in the experiment.

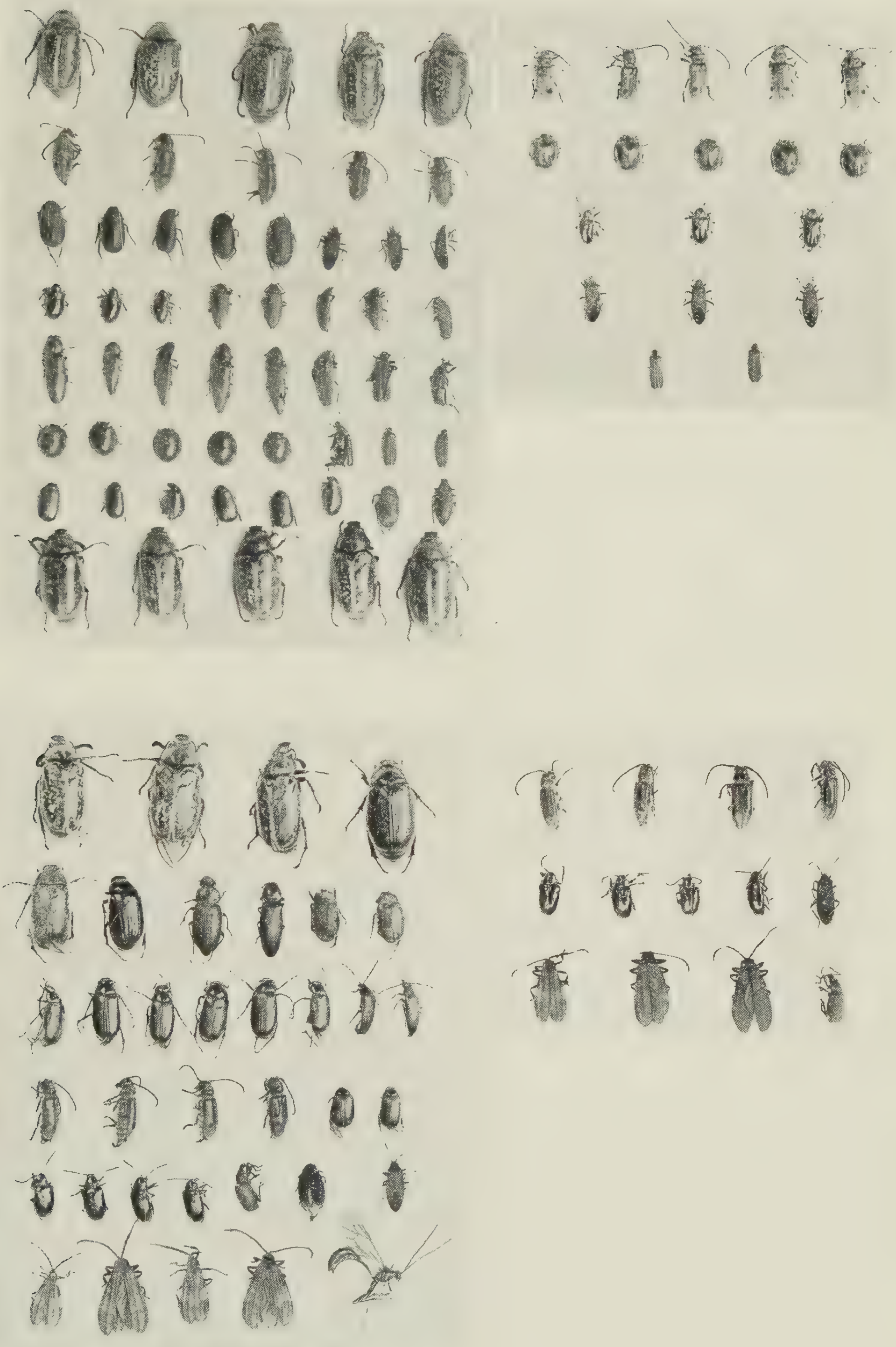
Plate XXII.

Above. Bird-tray Experiment XXIX, July 14, 1931.

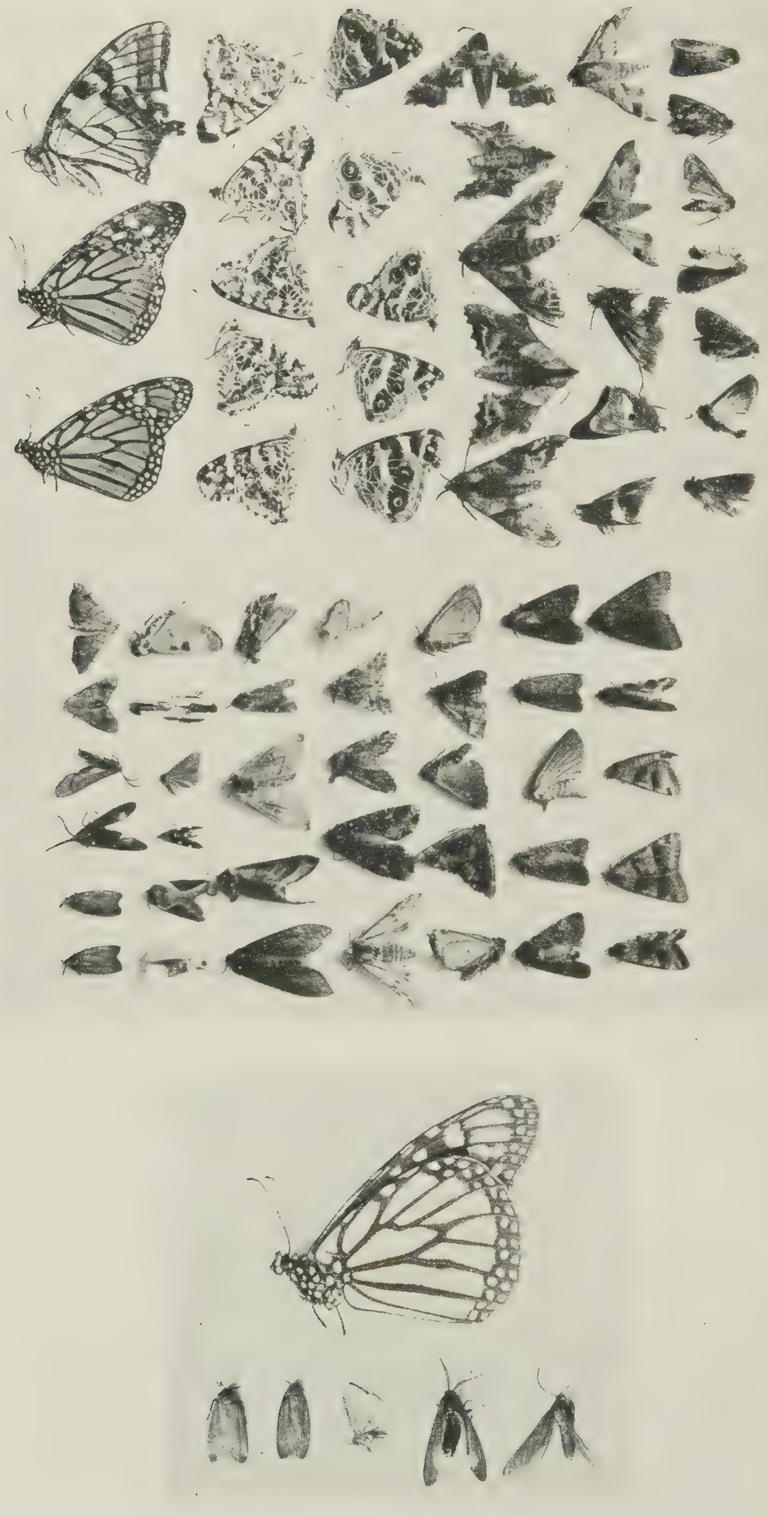
This experiment began with 55 insects of 14 species (left), and at its termination there remained 18 insects of 5 species, these being all of the 5 species included (right).

Below. Bird-tray Experiment XLI, July 28, 1931.

This experiment began with 36 insects of 17 species (left), and at its termination all (22) of 12 species had been eaten, whilst all but 1 of 5 species remained. The tray was visited 22 times by 4 species of birds.



Bird tray experiment XXIX (above) and XLI (below).



Bird tray experiment XLIV.

PLATE XXIII.

Bird-tray Experiment XLIV, August 4, 1931.

Above. 67 insects of 29 species were offered in this experiment.
Below. There remained at the termination 6 insects of 4 species of which 5 represented all the specimens of the species offered.

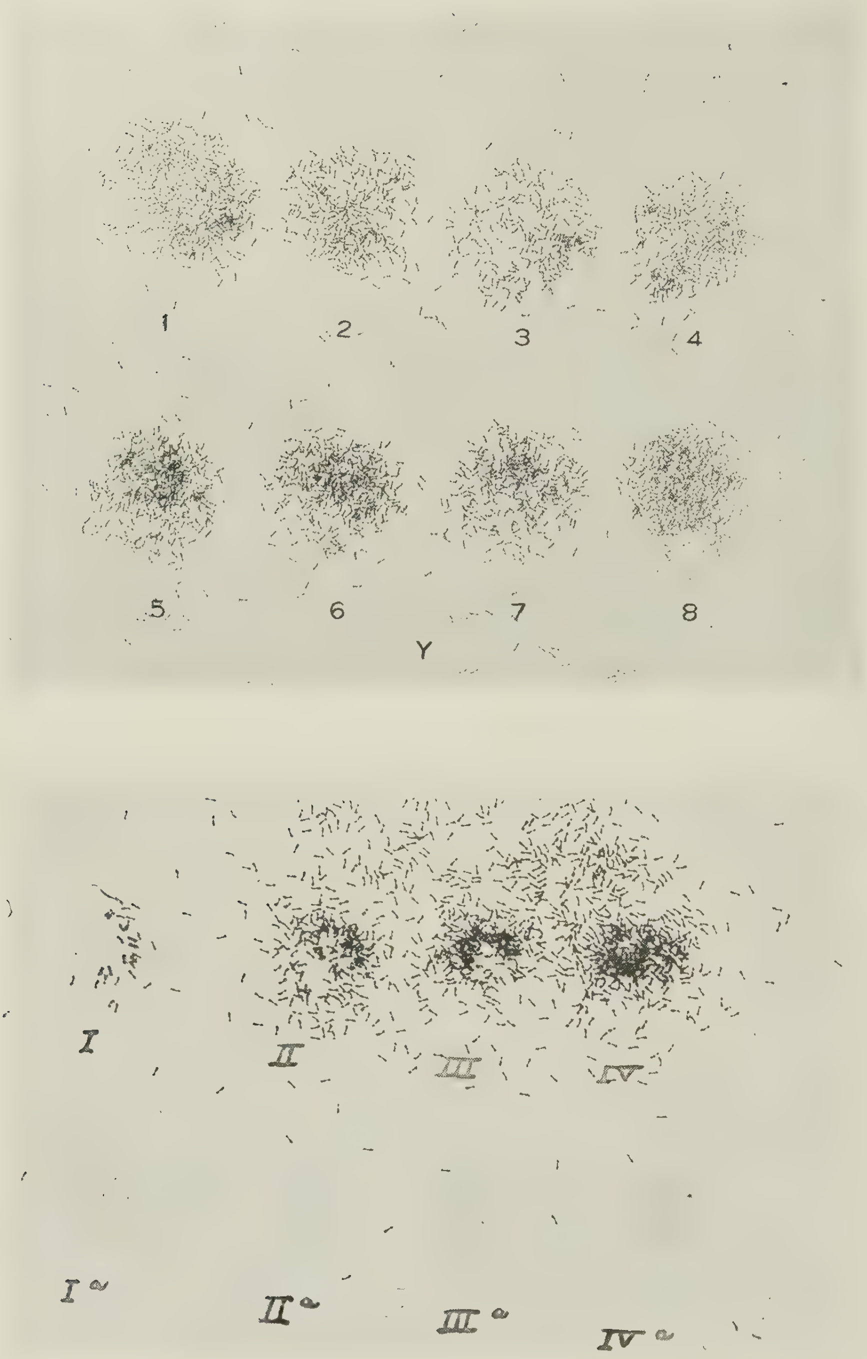
Plate XXIV.

Bird-tray Experiment XXXIII, August 4, 1930.

Above. As photographed before placing on the tray, this experiment included 83 insects of 4 orders and 20 species.

Below. At its termination 22 specimens remained, of these 16 were *Calopteron reticulatum* showing 80% uneaten. Of the other beetles only 2·6% remained uneaten.

Bird tray experiment XXXIII.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Ant experiments Y (above) and VI (below).

Plate XXV.

Above. Ant Experiment Y.

All tests were made with amyl acetate extracts combined with cream. The even distribution of the ants indicates no deterrent in any of these insects. The photograph was taken after 7 hours' exposure to the ants.

Fig. 1. *Euchlaena johnsonaria*, Fitch.
2. *Hyphantria cunea*, Dru.
3. *Lagoa crispata*, Pack.
4. *Calocalpe undulata*, L.
5. *Isia isabella*, A. & S.
6. *Nomophila noctuella*, D. & S.
7. *Macrodactylus subspinosus*, F.
8. *Ellopia pellucidaria*, G. & R.

Below. Ant Experiment VI.

All tests were made with *Syntomeida epilais*, Walk. (Lep. Syntomidae), and check tests with the various solvents employed, all similarly combined with fresh cream. The photograph was taken after 5 hours' exposure to the ants, at which time all the check tests were being attacked (that containing chloroform less vigorously), and none of those containing infusions of the insect were being touched.

I.	Chloroform.	Ia.	*Syntomeida epilais* in chloroform.
II.	Amyl acetate.	IIa.	,, ,, in amyl acetate.
III.	Alcohol.	IIIa.	,, ,, in alcohol.
IV.	Water.	IVa.	,, ,, in water.

Plate XXVI.

Upper. Ant Experiment VII, July 9, 1930.

I.	*Chrysopa* sp. in amyl acetate.	Ia.	Cream only.
II.	*Tetraopes* in amyl acetate.	IIa.	Cream and amyl acetate.
III.	*Tetraopes* in alcohol.	IIIa.	Cream and alcohol.
IV.	*Syntomeida epilais* in amyl acetate.	IVa.	Blank.

The obvious avoidance of II and III (*Tetraopes tetraophthalmus*) was later modified by slow attack, but the next day IV (*Syntomeida epilais*) was still entirely undisturbed. Cream was used in all tests, and the photograph taken after 3 hours' exposure to the ants.

Centre. Ant Experiment E, July 20, 1931.

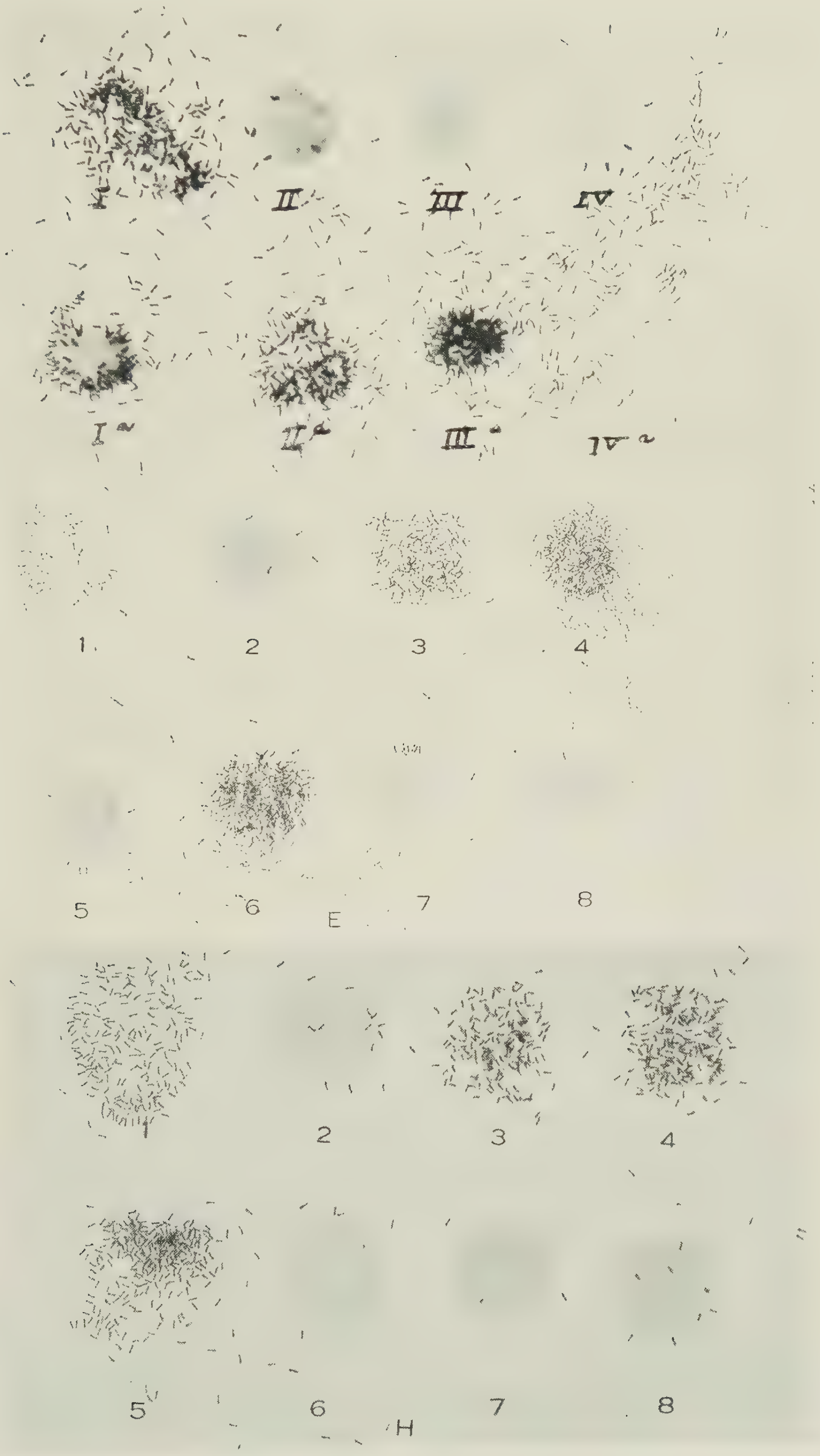
Fig. 1. Cream and amyl acetate.
2. *Tetraopes tetraophthalmus*, Frst.
3. *Ellopia pellucidaria*, G. & R.
4. *Euchaetias egle*, Dru.
5. *Labidomera clivicollis*, Kirby.
6. *Scepsis fulvicollis*, Hbn.
7. *Lygaeus kalmii*, Stal.
8. *Chrysochus auratus*, F.

All the tests were made with insect extracts in amyl acetate combined with cream. Note that numbers 3, 4 and 6 seem more attractive than 1 (the check test), which consisted of cream and amyl acetate alone. Photographed after 7 hours' exposure to the ants.

Below. Ant Experiment H, July 27, 1931.

Fig. 1. Amyl acetate (check test).
2. *Lygaeus kalmii* in ac. 30 days.
3. *Hypoprepia miniata* in amyl acetate.
4. *L. kalmii* (dry) in amyl acetate.
5. *Scepsis fulvicollis* in amyl acetate.
6. *L. kalmii* (dry) in water.
7. *L. kalmii*, dry.
8. *L. kalmii*, fresh.

In this experiment all tests were made with the insects reduced to fragments or infusions and combined with cream. In numbers 4, 6 and 7, six dried *L. kalmii* were reduced to fragments, divided into three portions and used as indicated. The acceptance of number 4 is possibly due to an error of technique, since in twenty of the twenty-three tests with this insect refusal was as definite as that indicated by numbers 2, 6, 7 and 8. Photographed 8 hours after exposure to the ants.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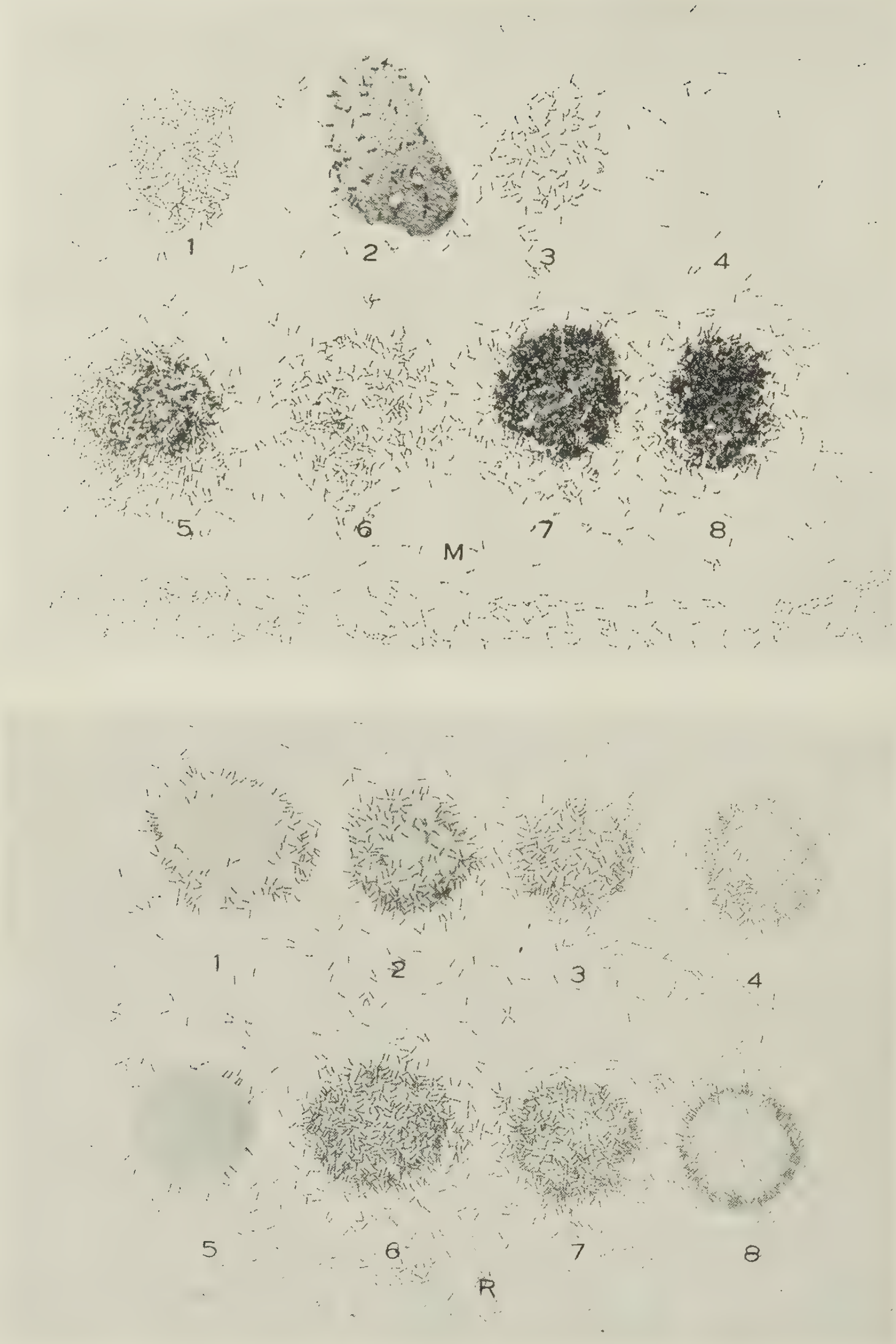
Ant experiments VII (above), E (centre), and H (below).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Ant experiments M (above) and R (below).

PLATE XXVII.

Above. Ant Experiment M, August 1, 1931.

FIG. 1. Check test, cream only.
2. *Danaida archippus*, larva.
3. *D. archippus*, larva in amyl acetate.
4. *Lygaeus kalmii* in amyl acetate.
5. *D. archippus*, adult.
6. *D. archippus*, adult in amyl acetate.
7. *Papilio philenor*, adult.
8. *Papilio polyxenes*, adult.

The chief significance of this experiment lies in the test of both larva and adult of *Danaida archippus.* As usual, the insects were macerated in cream, or an infusion of the insect (in amyl acetate) was combined with cream. At the expiration of two days, all the tests had been cleared from the slab by the ants with the exception of number 4—*L. kalmii,* which was still undisturbed.

Below. Ant Experiment R, August 8, 1931.

FIG. 1. *Tetraopes* in amyl acetate.
2. *Epicauta marginata* in water.
3. *Epilachna borealis* in amyl acetate.
4. *Apicia confusaria* in amyl acetate.
5. *Tetraopes* in water.
6. *Epicauta marginata* in amyl acetate.
7. *Epilachna borealis* in water.
8. *Malthaca dimidiata* in amyl acetate.

All the tests were made with insect extracts combined with cream. Of the insects tested *Tetraopes* alone, numbers 1 and 5, showed avoidance, and its extract in amyl acetate was slowly attacked. The photograph was taken after 3 hours' exposure to the ants.

PLATE XXVIII.

Above. Ant Experiment S, August 10, 1931.

FIG. 1. *Lygaeus kalmii*, in amyl acetate 7 weeks.
2. *L. kalmii*, dry; in amyl acetate 2 hours.
3. *L. kalmii*, dry; in water 2 hours.
4. *Photinus consanguinius*, Lec., in amyl acetate 30 days.
5. *Necrophorus orbicollis*, Say, in amyl acetate 5 weeks.
6. *Photuris pennsylvanica*, De G., in amyl acetate 4 weeks.
7. *Nacerda melanura*, L., in amyl acetate 5 weeks.
8. *Cantharis rotundicollis*, Say, in amyl acetate 4 weeks.

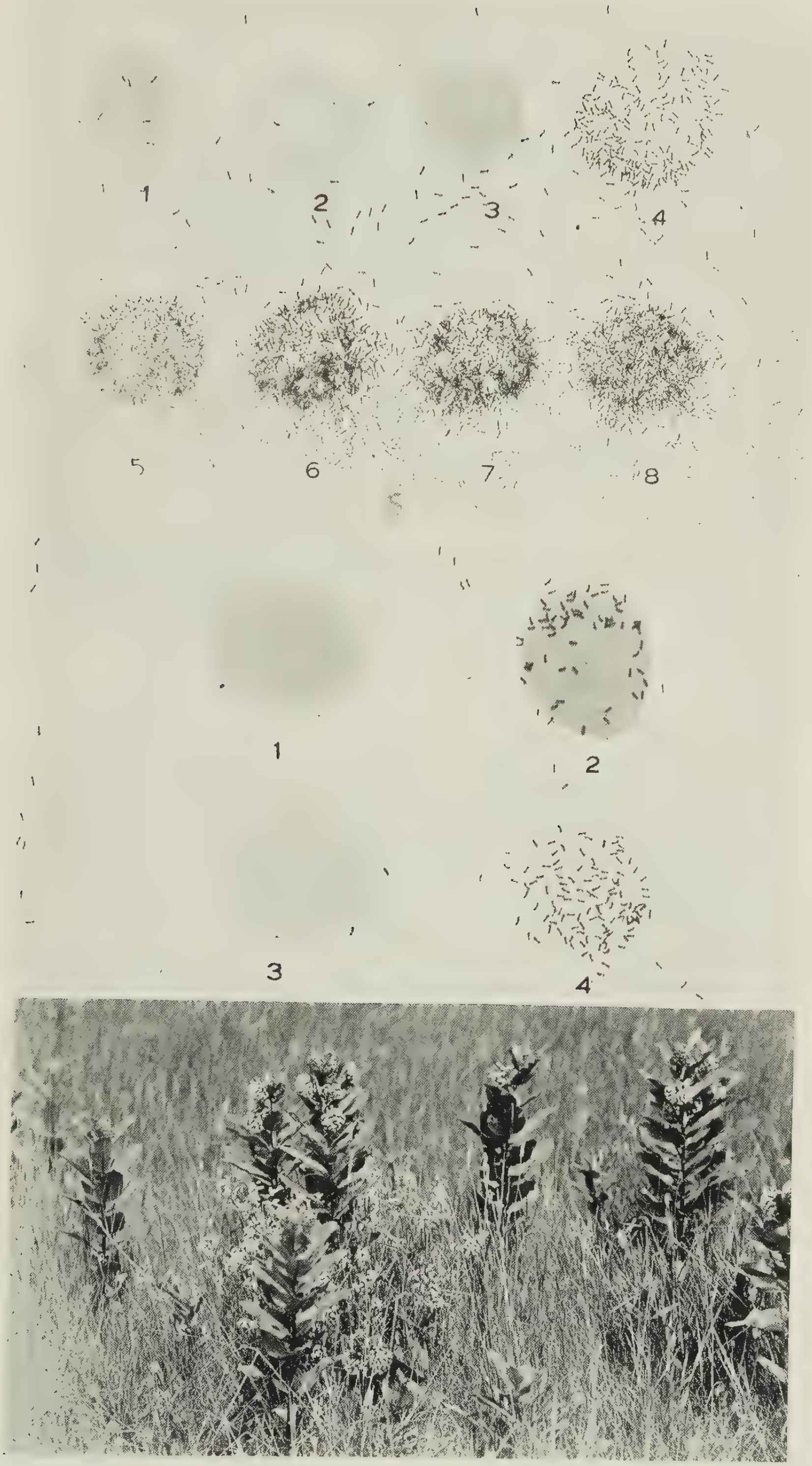
In this test all were combined with cream. The uniform avoidance of *L. kalmii* under varying conditions and in comparison with sundry beetles is significant. After 48 hours, numbers 1, 2 and 3 (all *kalmii*) were still undisturbed, whilst all the others were completely eaten. Photograph taken after 5 hours' exposure to the ants.

Centre and Below. Plant material experiment with *Asclepias syriaca*, L., September 6, 1931.

FIG. 1. Cream and fresh latex.
2. Cream, infusion of dried leaves.
3. Cream, infusion of dried latex.
4. Cream only (check test).

In number 1, the fresh latex was thoroughly mixed with twice the volume of fresh cream; number 2, the dried leaves were steeped for two hours in the least possible quantity of water and then combined with cream; number 3, the latex was dried on strips of clean paper, these then steeped in water, which was combined with cream; number 4, strips of the same paper (with no coating of latex) were steeped in water, which was then combined with cream as a check test. The photograph was taken after 6 hours' exposure to the ants.

The lower figure is *Asclepias syriaca*, L., in a meadow.



Ant experiment S (above) and plant material experiment with *Asclepias syriaca*, L. (centre and below).

INSECTS AND OTHER INVERTEBRATES FOR HUMAN CONSUMPTION IN SIAM

T.O.
J.R.

By W. S. Bristowe, M.A., F.Z.S.

(Communicated by Prof. E. B. Poulton, F.R.S.)

[Read 1st June, 1932.]

With One Text-figure.

Considering how relatively simple are the food requirements of man it is surprising to find how diverse is his menu. He satisfies his needs, the needs that are common to the whole race, in vastly different ways in different countries. To some extent this is due to climatic effects on him. An Eskimo who revels in seal flesh and blubber, for instance, would be nauseated by a similar diet in the tropics, and would fade away with rice as his staple food in Greenland. But leaving aside any climatic influence, one would expect man's sense of taste to tell him what he likes and his pocket to dictate as to what he can afford to eat—and yet this is by no means how his diet is selected in practice. For a number of reasons, some of which I will outline, he does not always give his sense of taste a chance, and so it follows that his pocket is not consulted.

Religion. Some animals are deemed unclean and others sacred. Most pagan tribes have their tabus—in some cases animals into which their spirits are believed to pass at death. Then, according to strict Hindu and Buddhist teaching, life may not be taken, so vegetarianism would ensue were not the adherents of these religions able to absolve their consciences by allowing others to kill for them, or for fish taken out of water to die of their own accord. Japan might now be an important dairying country but for the introduction of Buddhism at a time when that seemed likely.

Magic. There is a widespread belief that the mental and physical qualities of an animal are transferred to the person who eats it. The consequence of this is that many races avoid eating slow-moving or cowardly animals, no matter how succulent they may be to the palate, and seek the swift-moving or brave animals, so that they themselves may acquire these properties.

Imagination and Conservatism. It is not uncommon to meet people who "hate" things they've never tasted. Sometimes this is due to their sense of smell and sometimes sight. Englishmen have acquired the taste for Gorgonzola cheese; Eastern races are repelled by the smell. In the case of the durian fruit the reverse applies.

The appearance of food, and even the name given to a dish, makes a great difference, and a successful chef must be an artist versed in colour schemes as well as a cook. For the British market eggs and kippers are sometimes dyed brown, and butter yellow. Yet the daintiest British dishes would be deemed clumsy and unattractive by the Japanese, and their appetites would not be whetted. In China cakes and drinks are dyed bright yellow or red.

Fear prevents our making use of more than one of the excellent fungi that grow in Great Britain, whilst conservatism leads us to neglect many of the delicacies of other nations. The idea of even trying some of them makes many of us shudder.

It is thought that at one time man's ancestors were vegetarians and that somewhere in their history they changed and became flesh-eaters. At the time of the transition, or perhaps before, as monkeys eat insects, they would be liable to fill in the gaps when game was scarce with smaller things like insects which were easily obtainable. And this is the stage in dietary development in which many of the more primitive races live to-day. The Australian aborigines, the pygmy, and certain other negroid races of Africa are said to eat termites and several forms of grubs, whilst in Malaya the negroid aborigines (Semang) told me they ate queen termites and the larvae of a greenish coconut beetle. Closer investigation would probably show that many of the hunting tribes which have not learnt the art of cultivation, value as food quite a wide range of insect life, but with the advent of agriculture other factors came into play which discourage the continuance of an insect-eating habit. With agriculture came an increased density of population. A given area cultivated with crops can support a far greater number of people than a similar area stocked with a hunting race, so it follows naturally that the available supplies of insects cannot any longer form a substantial part of their menu. Then the growth of trade with other countries produces a wider choice, and from this it would follow that many of the more insipid insects would be discarded. However, that habit has been continued amongst many races after the agricultural stage in man's development was reached, and it is indulged in far more widely than is usually recognised. To cite a few examples, the Samoans catch Palolo worms (*Eunice viridis*) at their biennial swarming periods, natives of all countries where Locusts abound collect them for food, scarabs are eaten by the Bedouins, cockroaches and silkworm chrysalids by the Chinese, spiders by the Lepchas of India, termites and certain larvae by the Javanese, water-bugs by the Mexicans, cockchafers by Italian peasants and, unwittingly, the British eat cochineal insects and cheese mites!

On arriving in Siam I was informed that the Laos ate insects; so I set out to investigate with a view to making a list of those they collect and discovering whether they really like them or were driven to make use of them by economic necessity.

Although the list of insects that I give for Siam is probably far from complete, I am confident that it includes the main kinds. Specific distinctions are frequently difficult without the use of a lens or microscope, and it would be asking too much of the Laos to expect them to eat one species and discard a closely allied one. The Lao or Siamese names are in fact seldom specific and only so when a species has no relations resembling it closely in appearance. More often than not one name covers one or more genera or even families in the case of insects that have little use as medicine, food or ornaments, such as dragonflies.

As regards their reasons for eating insects, I found that without question the Laos like them. Some fetch high prices and the capture of others is fraught with considerable risk. What is more, so would we like them if they were suitably disguised and if we gave ourselves the chance of acquiring the taste. Of this I convinced myself by sampling most of the main kinds myself—spiders, dung beetles, water-bugs, crickets, grasshoppers, termites and cicadas—and found none of them distasteful and a few quite palatable, notably the giant water-bug. For the most part they were insipid, with a faint vegetable flavour, but would not anyone tasting bread, for instance, for the first time, wonder why we eat such a flavourless food? A toasted dung beetle or softbodied spider has a nice crisp exterior and soft interior of *soufflé* consistency which is by no means unpleasant. Salt is usually added, sometimes chilli or the leaves of scented herbs, and sometimes they are eaten with rice or added to sauces or curry. Flavour is exceptionally hard to define, but lettuce would, I think, best describe the taste of termites, cicadas and crickets; lettuce and raw potato that of the giant *Nephila* spider, and concentrated Gorgonzola cheese that of the giant water-bug (*Lethocerus indicus*). I suffered no ill effects from the eating of these insects.

That the Lao is driven by force of necessity to eating insects seems unlikely. In appearance and general mode of life, he is practically indistinguishable from the Siamese. Both are peasants and padi-growers, and both are poor, but the Siamese do not make a general practice of eating insects. Statistics are incomplete, but Professor Carle Zimmerman, of Harvard University, in a report on his investigations in Siam * shows that out of 9,428 persons examined in various country districts of Siam, there were 30 clear cases of diet deficiency, of which no less than 25 were beri-beri occurring in districts where milled rice had recently been introduced. This would appear to indicate that enough suitable food is obtainable in the ordinary way without resorting to insects, but I ought to record that my own investigations up-country show that the Laos are more energetic as farmers than the Siamese, whilst employers of labour testify to their greater stamina and hard-working properties.

An analysis of Professor Zimmerman's results shows the average daily food of one adult Siamese peasant to be as follows :

Rice	693 grams (glutinous), or, 553 grams (non-glutinous).
Fresh fish	6 to 25 times per month.
Fermented fish	27 grams.
Fish or shrimp sauce	10 grams.
Shrimp paste	14 grams.
Green beans	6 to 25 times per month.
Salt	10 grams.
Eggs, chicken, pork, beef, shrimps and shellfish—seldom	1 to 5 times per month.

Lao food is similar with the addition of insects which are eaten in considerable numbers at the particular season in which each occurs. It will be seen from what has been said above that the basis of the diet is rice, which contains 75% carbohydrates, 13% moisture, 8% protein and 1% fats. Fish represents the main protein constituent of their diet and, in the seasons when fresh fish is not available, fermented fish, shrimp paste, or dried salt fish are consumed. The protein content of fermented fish and shrimp paste are 18 and 23% respectively, and the fat content 6 and 3%; insects have a high protein content, and some lightly roasted spiders, *Melopoeus albostriatus*, Sim., that are widely eaten by the Laos had, according to an analysis carried out for me by the Bangkok Government Laboratory, a protein content of 63·4% and a fat content of 9·8%. As I shall mention elsewhere in this paper a Lao and I, hunting and digging together practically as one man, collected six of these spiders, which together totalled approximately ½ lb. in weight, in an hour. This was during the dry season when the giant water-bug and some other kinds of insects are unobtainable or very scarce, and it would appear that some kind of insect is always in season. For purposes of convenience I use the term "insect" loosely throughout this paper to include Arachnids.

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* Siam Rural Economic Survey, 1930–31. Issued by the Siamese Ministry of Commerce and Communications in October 1931.

The part played by man, and the Laos in particular, in controlling pests is probably greater than might be imagined. I give a few examples below. Much damage is done to young padi by freshwater crabs such as *Potamon* (*Paratelphusa*) *sexpunctata* and *P. siamense.* The crabs nip off the young stems and may do very serious damage if left to multiply unchecked. Fortunately a taste for their flesh has been acquired, and they are to be seen on sale in some of the up-country villages. At Klong Rang Sit, for instance, I found that five crabs cost one satang, but in hunting for these the farmers can also catch the various species of edible frogs (of which the most popular appear to be *Rana tigrina,* Daud., and *R. limnocharis*), which fetch at least 5 satangs each in this same district. In Kedah, where ingenious bamboo traps are employed for catching the crabs, more than 500 are frequently collected off a single acre. At Nong Khae I saw the shells on sale in the market and was told that these are incorporated in a cough cure. It was at Nong Khae also that the farmers use magic to rid themselves of this pest. At the beginning of the planting season one crab is taken from the field to the village priest, who then exhorts it to mend its ways and to persuade its fellows to leave the farmer in peace. A mystic sign is inscribed on its back and it is released in the field from which it was taken. Should this means fail to be effective, the farmer has no compunction in carrying out a ruthless slaughter of these disobedient subjects.

Various kinds of water snake and cobra are eaten by the Laos, Siamese and Chinese in Siam, and some, notably the common cobra, *Naja naja,* are credited with aphrodisiac properties. Major Ladell tells me that an increasing demand in recent years has made itself felt to such an extent that the common cobra is now quite scarce round Bangkok.

Shipworms (Teredidae) do considerable damage in Siam to piling, boats and submerged wood in salt, brackish and even fresh water. These are highly esteemed as an article of food by Siamese and Laos.

The larvae of timber-boring and stem-boring Longicorns and weevils are sought by the Laos, as are a number of other pest insects of which the following list is an example :

Beetles.	*Rhyncophorus schach,* Fab. Larva does considerable damage by boring in coconut palms.
,,	*Xylotrupes gideon,* Linn. Adult damages coconut and sugar palms.
Locusts.	*Patanga succincta.* } damage padi.
,,	*Locusta migratoria.*
Moths.	*Xyleutes leuconotus.* Larvae damage *Casuarina* trees.
,,	*Zeuzera coffeae.* Coffee borer. Larvae occasionally on the Bangkok market.
Bees.	*Xylocopa confusa.* Damages woodwork.
,,	*Xylocopa latipes.* Recently did considerable damage to cables in Bangkok.

The Laos are called "dirty feeders" by the Siamese on account of their insect-eating habits, and in particular, of their liking for dung beetles and their grubs, so they are somewhat sensitive to being questioned. However, in a peaceful setting, with Lao music being played and native brandy provided their tongues were soon loosened—especially when they learned that I had come not only to question them but to eat the things they ate. Actually the Siamese will themselves eat some kinds of insects, though they do not make such a general practice of it. Giant water-bugs are added to royal sauces, Duang grubs (*Zeuzera coffeae*) were much prized by the late king, and certain kinds of ant and ant grub are pickled for the consumption of good family Siamese in Bangkok. Wasp grubs and honey, locusts, crickets and even big Mygalomorph spiders are occasionally eaten by some of the Siamese peasants.

The Lao headquarters are in northern and eastern Siam, but it may be said that they are scattered throughout the whole country. I myself questioned Laos in the north (Lampang, Chiengmai), in the central plain (Klong Rang Sit, Nong Khae, Sadaburi), in the south (Hua Hin) and in Bangkok, and I caused inquiries to be made in the centre (Packnampo) and extreme south (Patani). In Bangkok I was enabled, through the kind assistance of Dr. Carthew, to question Laos residing in that city but originating from practically every part of Siam; from Chiengmai, Chieng Rai and over the French border in the north; from eastern localities extending beyond the borders of Siam as far as Battambang (Cambodia); from Ubon, Korat, Roi Et, Pakao, Payook Daan, Calar Sedon and Suphan. Their choice of insects seems to be remarkably consistent in every area and also the order of preference, the most popular being the giant water-bug, dung beetles and their larvae, Mygalomorph spiders, grasshoppers, and the larvae of Hymenoptera, beetles and moths.* Exceptions include scorpions which do not appear to be eaten in Chieng Rai or Battambang, dragonflies which are eaten only in the Ubon area though their nymphs are collected at Hua Hin, and cockroaches which in most areas are said to "stink" but are eaten at Korat and Hua Hin. The eggs of cockroaches are fried and eaten by children in all districts. Of course some insects, notably a cicada, *Dundubia intemerata*, have a restricted range and are therefore not known in other districts.

The powers of observation of individual Laos varies considerably, but some have a remarkable knowledge of the structure and life-habits. Their descriptions of the structure enabled me to identify the majority of species about which they spoke, but in all cases I have secured confirmation either by being brought specimens or else, in a few cases, by showing them specimens borrowed from Major Ladell's collection of Siamese insects in the Agricultural Department at Bangkok. For the naming of species I owe much to the assistance of Major Ladell in Bangkok and Mr. H. M. Pendlebury of the F.M.S. Museum in Kuala Lumpur. The Lao knowledge of life-histories surprised me, and in some cases at least this knowledge has led them to devise ingenious methods of capturing insects (vide *Cicada*, *Vespa* sp.).

The Lao and Siamese names that I record are spelt as nearly as possible to sound like their pronunciation of them.

ARACHNIDA.

Scorpions.

There do not appear to be many different kinds of scorpions in Siam, and it is possible that all are classed under two Siamese names, Mang pong and Mang pong chung, and that all kinds are eaten.

Mang pong is the name given to the small light-coloured scorpions, of the genus *Tityus*, for instance, which appears to be the commonest. These are only about two inches in length and are found under stones. The Lao name is Mang now.

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* Up to 4*d*. may be paid for a single *Helicopris* dung beetle or giant water-bug.

Mang pong chung is applied to the large dark brown scorpions of the genus *Heterometrus*, which they find in the more jungly areas. These reach a length of six inches or more, and there are probably several species besides *H. longimanus* and *H. oatesii.*

There appears to be no trade in them, probably because they are not sufficiently abundant, but they are said to have a very savoury smell when roasted and are sometimes eaten raw after pulling off the sting. Laos from Battambang (Cambodia) and from the French territory to the north of Chieng Rai denied eating scorpions; but everywhere within the borders of Siam they appear to be relished.

The scorpion-eaters of N. Africa are more in the nature of medicine-men. They are met with in various parts of Northern Africa, certainly Morocco and Egypt, and Miss F. Finch gave me the following first-hand information. The profession goes in families, and by heredity the members of these families are said to be immune to scorpion stings. They are also said to owe their immunity to eating the scorpions.

If houses in villages are opened after a period of disuse, it is frequently found that quantities of scorpions have taken possession, so the scorpion-eaters are called in to collect them. Miss Finch watched them doing this in a village school near Luxor just before the holidays came to a close. A scorpion-eater squatted on the floor in the centre of the room and started to whistle softly. To her amazement she saw scorpions appearing from their hiding places and walking across the floor towards him.* Whenever one came in reach the scorpion-eater reached out an arm and with no apparent fear picked it up and put it in a bag. After he had collected quite a number he rose and left the building, saying the building was now free of them. Miss Finch accompanied him to his home and there saw him and his family eat them mixed with the small grain of some cereal.

The stings of some scorpions in Egypt cause death to small children, but the scorpion-eaters can save them, so Miss Finch tells me. Scorpions are left in vinegar for five months and the child is made to eat them after they have been taken out of the pickle and pounded up, whilst the liquid is rubbed into the affected part.

SPIDERS.

Laos from all districts appear to eat two different types of spiders—the giant orb-webbed *Nephila* and the large hairy Mygalomorph "bird-eaters." The two commonest spiders are *Nephila maculata*, Fabr., and *Melopoeus albostriatus*, Sim. Both these species have been collected and brought to me by Laos, and from their descriptions it is evident that they eat the allied *Nephila imperialis*, Dol. The orb-weaving *Argiope* are caught by some of them, and at Battambang a Lao told me that they will eat any spider of reasonable size.

Nephila maculata, Fabr.
Mang yung sing : Lao name.
Mang moom tong : Siamese name.

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* Some scorpions can whistle or hiss, and it is possible that this is used as a mating signal as well as to frighten away enemies, which is the usual explanation. If such is the case, the scorpion-eater's whistle may have the same effect as the mating whistle and explain why scorpions of one sex at least are attracted to him.

The Siamese name means "the golden one," which shows that the golden threads of this species have not escaped their notice. One Lao confirmed what other observers have written—that the powerful snare sometimes entangles small birds, and he said that he had seen the spider wrap them up in silk, bite them and wait for them to die. Sometimes Laos will pick these spiders out of their webs, pull off their legs and eat them raw, but it is more usual to roast them. When roasted and dipped in salt the abdomen, which is the only part eaten, has a not unpleasant flavour which reminded me of raw potato and lettuce mixed. The Lepchas of Northern India are also said to eat this species.

Melopoeus albostriatus, Sim.
Tooa boong : Lao name.
Tooa mang moom par : Siamese name.

I have been out collecting these fine blue-legged spiders with a Lao at Hua Hin and we found six adult females in an hour. Each one measures nearly 2½ inches in length and weighs about 1⅓rd ozs., so our total catch weighed ½ lb. The chelicerae are removed and the spiders roasted on a stick. This process removes the hair. The whole spider is then eaten with salt or sliced up with chillies. The taste reminded me of the marrow of chicken bones. When eaten raw, as is sometimes the case, the hairy skin is slit open and the inside extracted. The eggs are eaten raw.

In answer to the question : "Are they highly valued ? " I got an answer which can be translated literally : "Find a hole and I will not leave it for another occasion." The burrows which are closed with a thin transparent silken covering during the day, are about 1 ft. deep, straight but slightly slanting. Near the end it broadens out and in this chamber I found remnants of beetles that the spider had devoured and tiny living woodlice and minute brown beetles, both of which, presumably, acted the part of scavengers. When the spider has been dug out the head is held down with a stick and with the other hand it is picked up and the chelicerae pulled out. The spider is then skewered on to a sharp stick ready for roasting. Sometimes they appear in the village market at Hua Hin at 2 satangs each (¾*d.*).

Either this or allied species are eaten by Laos, and occasionally Siamese, throughout the whole of Siam and the Shan States. The Karens also eat these spiders, according to an informant in Lampang, and the Burman tribesmen of Tenasserim collect the eggs with a forked stick and eat them raw. Dr. L. Fage tells me that Annamites and Laos of Cambodia eat the abdomen of the same species.

King Crabs.

Tachypleus gigas. This species is hunted along the Siamese coast on account of its eggs, which are highly prized. The eggs are abundant and are attached to the female, who is sold for as much as 10*d*. although she herself is not eaten. The eggs look somewhat like caviare—but taste like potato ! Some sour flavouring is usually added, and sometimes they are eaten in curry. Both Laos and Siamese eat them.

The Siamese name for this king crab is Mang daar talleye. An indolent husband who leaves everything to his wife or a man who cannot resist "the lusts of the flesh, the pomps and vanities of this wicked world," is called a Mang daar talleye on account of the habits of the male *Tachypleus*, who remains clinging to the female even after the eggs are laid.

INSECTA.

Beetles.

The larvae of a number of Longicorn and other families of beetles are eaten by the Laos, but the actual beetles into which these hatch I was in most cases unable to determine owing to the brevity of my visits. The highly treasured larvae referred to in the following account I am unable to assign even to a family, but the amount of detail contained in the account leads me to believe that it is essentially true.

On the borders of Siam and Burma, at Suphan, there live a very shy tribe of Laos who avoid association with their more highly civilised neighbours as much as possible. They shoot the long-tailed Kharng monkey (*Presbytis*), make a long abdominal incision and extract the intestinal contents. The body cavity is stuffed with leaves of Bai Makrut (*Citrus hystrix*) and other herbs and the cut is then sewn up. They then go and split open a termite mound and make a paste of the interior portions, with which they smear and completely cover the dead monkey's body before they proceed with the next step of hanging it up on the branch of a tree. A dish is placed beneath the hanging monkey and the juice that drops into this is called Nam phla kharng (monkey sauce)—a delicacy well known in Siam. After the monkey has been hanging for a week or two, blow-fly (?) maggots begin to fall into the dish, and until they cease to appear the monkey is left where it is. When no more fall the remaining shell is cut open and two or three special big maggots of a different kind are found inside. Judging by the description—"legs and a dark mouth with jaws"—this is a beetle larva. As many coconuts as there are larvae are collected and heated in their shells, a hole is bored in the top and, when the liquid is cool, one larva is introduced into each. The hole is now closed with termite paste, the coconut is swathed with cloth and this in turn is enclosed in termite paste. For about three weeks this "mummy" is stored away and then, when it is split open, a white grub "the size of a tangerine orange" is found practically filling the interior of the coconut. How great a delicacy this is can be gathered from the fact that to buy *one* would cost 7 or 8 rupees (say 12/-) which is a fortune to these country folk. They are eaten at ceremonies and on special occasions.

Can the larva feed on such different things as decaying monkey and coconut, or is it not more likely that it dies on being placed inside the coconut and in the course of three weeks gets puffed out to "the size of a tangerine orange"?

Fam. Rutelidae.

Adoretus compressus, Web.
,, *convexus*, Burm. } Small Rose Beetles.

Mang ee noon : Lao name (see Melolonthidae).

A Lao from Wien Chun told me about these beetles, and the others agreed with the description and identified specimens. They are very popular throughout the Ubon circle but do not come on the market. They catch them at night when they come to the light in swarms, roast them and pull off the wing cases.

Fam. Buprestidae.

Sternocera equisignata, Saund.

Mang Khup : Lao name.
Mang Thup : Siamese name.

This unfortunate wood-borer is sought not only by the Laos for food but by the Chinese for decorative purposes, the metallic green and gold elytra being used in clothes, jewelry and ornaments. The Chinese breed them for this purpose, and in Bangkok they fetch 1 satang or approximately $\frac{1}{4}$*d.* each.* The Laos pick them off shrubs, roast them over a fire and squeeze out the faeces before eating them. These beetles are $1\frac{1}{4}$ inches in length.

Fam. DYTISCIDAE.

Cybister limbatus, Fab.

Mang mee-eng : Lao name.

A black shiny water beetle slightly more than one inch in length. They catch them in nets (probably when primarily hunting for fish) and roast them.

Fam. DYNASTIDAE.

Oryctes rhinoceros, Linn.

Mang bough : Lao name for larva.
Mang kwang : Lao name for adult.

Larvae, pupae and adults are searched for amongst cow and buffalo dung—especially in sheds where either have been. The beetles are dark chocolate brown and $1\frac{1}{3}$rd inches in length. The males have one horn on the top of the head and an excavation out of the front part of the thorax. The female has similar characters less well-developed. Children are said to attach the beetles to the backs of their heads on account of their " aeroplane buzz " and the cool draught they make when they vibrate their elytra in an attempt to escape—but when their parents get hold of them they are cooked ! They are usually roasted, but sometimes fried. Sometimes they are used in curries and sometimes eaten alone, after breaking off the elytra and hard parts.

The grubs and pupae are soaked in coconut milk for a quarter of an hour and then roasted. Their flavour is not strong and quite pleasant, but difficult to define. It is vegetable, not animal. Cooked in this way they have a crisp exterior and the consistency of a *soufflé* inside.

The beetles and grubs are highly prized, and it is due to their taste for these particular insects that the Laos rank so low in the Siamese estimation.

Xylotrupes gideon, Linn.

I discovered that this beetle is covered by the Lao name for the last species—Mang kwang. Both it and its larvae are also used as an article of diet, but there did not appear to be so much enthusiasm for this species as for the last.

The males are pitted in battle against one another, but so much money changed hands that a law prohibiting beetle fights was passed in Siam a year or two ago. It is the males, of course, who fight, and once one had managed to outflank the other the sound of rending chitin proclaims the end. The opposing horns from head and thorax can give a very powerful nip.

Helicopris sp.

Mang chew chee : Lao name.

A very large and possibly undescribed black beetle belonging to this genus, over two inches in length and broad in proportion, is found in Northern Siam.

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* H. M. Pendlebury tells me that *Chrysochroa fulminans,* a beetle with a somewhat similar appearance, is used by the Javanese for jewelry, etc.

It is used in medicine (see p. 403) and also as food. Seeing that each beetle was fetching as much as 20 satangs (say 4*d.*) when I was in Lampang in January 1931 a dung beetle farm might be a profitable enterprise! It is estimated that the average Siamese farmer's net income amounts to about 70 ticals—surely it would be easier to breed about 350 dung beetles (or say 400 to cover a middleman's commission)! It might be combined with breeding *Lethocerus indicus*, the water-bug, that fetches a similar price (see below).

The beetle is roasted, pounded up and then added to curry.

Onitis virens, Lansb.

Mang chew chee: Lao name.

Whilst out collecting with a Lao at Hua Hin we came upon this beetle in abundance amongst cattle dung, and he told me that the local Laos roast it with salt. It will be noted that the same Lao name is given to this species as to the last mentioned.

The habit of eating dung beetles is not peculiar to the Laos, for scarab Beetles (*Scarabaeus sacer*) are collected by Bedouins in Egypt and roasted with salt.

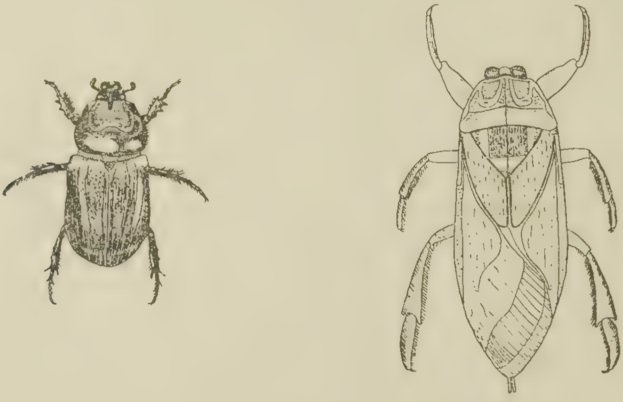

FIG. 1. *Oryctes rhinoceros*, L., and *Lethocerus indicus*, Lep. and Sev. ($\frac{1}{2}$ natural size).

When a boy reaches the age of 11 or 12 a ceremony initiating him to manhood takes place which has been described to me by Miss F. Finch from personal observation, as follows: A circle of men squatting on the ground surrounds the boy and a Sheikh. The men are shoulder to shoulder each touching his neighbour on either side of him. They chant in rhythm the 99 names of Allah, swaying from side to side and working themselves up to a pitch of great excitement. In less than half an hour, the men composing the circle and the boy seated in the centre are in a kind of trance. The Sheikh who has remained relatively calm and unaffected then reads extracts from the Koran relating to eternal life and commands the boy to eat from a bowl which contains scarabs, and the boy is then recognised as a man of the tribe or village.

Fam. MELOLONTHIDAE.

Lepidiota stigma, Fab.

Mang ee noon: Lao name.*

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* By some Laos at least this name seems to apply to all chafers and rose beetles.

Dr. Annandale mentions that the Laos near Pataling (S. Siam) make use of four species of Melolonthid for food, but gives the name of the present species only.

I showed this species to several Laos from the east and north of Siam and they all told me they ate it. Another chafer they eat belongs to the genus *Leucopholis*.

Fam. CURCULIONIDAE.

Rhynchophorus schach, Fab.

The adult and larvae of this large black weevil are sought for food. The larva is extracted from coconut palms infested with it, and roasted.

LONGICORNIA.

The larvae of several kinds of wood-boring Longicorns are extracted and roasted for food.

BUGS.

To see Javanese women picking what I believe to be lice from the heads of their friends and then like monkeys at the Zoo putting them in their mouths is a revolting sight that I have witnessed near Cheribon. And yet bed bugs (*Cimex lectularius*) were prescribed in medicine at one time as the following extracts show :—

> " Some men prescribe seven wall-lice for to drink,
> Mingled with water, and one cup they think
> Is better than with drowsy death to sink."
> *Moffet; Theatr. Ins.* 1634.

> " Shame not to drink three Wall-lice mixt with wine,
> And Garlick bruised together at noon-day,
> Moreover a bruised Wall-louse with an egg, repine
> Not for to take, 'tis loathesome, yet full good, I say."
> *Quintus Serenus.*

But there are other bugs of a less disgusting nature which are eaten by man for their taste alone.* Thus in Mexico there is a water-bug, *Corisella* (*Corixa*) *mercenaria*, Say, whose eggs are eaten as well as the insect (vide 1931, *Natural History Magazine*, **3**: 59). During the breeding season bundles of reed placed in the shallow water become encrusted with the eggs of this bug, known to the Mexicans as Axayacatl. These are collected and eaten alone or else mixed with meal and made into cakes which are eaten with green chillies. Lichtenstein says that the eggs of water-bugs serve as food in Egypt.

In *Oriental Cicadidae* published by the India Museum, 1889–1892, p. 22, W. L. Distant quotes the Rev. F. Mason, who describes clay tubes raised over a shaft sunk two or three feet in the ground from which Karens of Tenasserim extract cicada nymphs. He says they were deemed a great luxury.

Kingdon Ward, in his book *In Farthest Burma*, says that he saw his Nung porters searching in the shingle of a river bed for a species of bug " which when captured was decapitated between the fingernails and dropped into a bamboo tube. These bugs are fried in oil and eaten as a delicacy, despite their horrible odour ! "

Lethocerus (= *Belostoma*) *indicus*, Lep. and Sev.

Mang daar nah : Lao name (Nah meaning " land " is added to differentiate between it and the king crab, Mang daar talleye).

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* I am indebted to Mr. W. E. China of the British Museum (Natural History) for the two records that follow.

This is a giant water-bug measuring about two inches in length. It is a great delicacy which is shared by Laos and Siamese alike; it reaches the tables of princes in Bangkok. The bug is caught in water nets, and is said to prey on large insects and even frogs and fish.

The usual methods of preparing it for table are as follows: 1. Steam thoroughly and then soak in shrimp sauce. The insect is then served up and picked to pieces, each piece yielding a little meat from its inner side. The flavour is strong and reminiscent of Gorgonzola cheese. 2. After cooking, pound it up and use it for flavouring sauces, or curries. A popular sauce called Namphla is made by mixing shrimps, lime juice, garlic, and pepper and then adding Mang daar to finish up with. Vegetables are dipped into this sauce.

The price in Bangkok varies according to season from 5 to 20 satangs each (1*d.* to 4*d.*) and in the cold season, December to February, it is unobtainable.

I am informed that in Indo-China its essence is extracted and that this is on sale in small bottles in the towns.

Sphaerodema rustica, Fab. }
,, *molestum* } Lao name, covering both: Mang kharn.

These two small flat greenish water-bugs are both common in Siam, and, being similar in general appearance, it is not surprising that the Laos bunch them (and perhaps other species too) under one name. They collect these bugs by knocking them down with sticks from bushes in which they rest during the day. When several have been gathered they roast them in a dish and eat with the fingers like shrimps.

Laccotrephes grisea, Guer.

Mang dah: Lao name.

This water scorpion was brought to me by a Lao at Hua Hin. It is of a very thin papery nature, but was said to have a good flavour after being toasted on a bamboo skewer.

Dundubia intemerata, Walck.

Tua chuck-a-chun: Lao name.

It appears that this is the only species of cicada which is highly prized by the Laos and that it is either absent or rare in all except Southern Siam. One method of capturing the insects has been described by Dr. N. Annandale (1900, *Proc. Zool. Soc.*, **1900**: 859) and confirmed later by Mr. H. M. Pendlebury (1923, *J. F.M.S. Mus.*, **1923**: 11). On darkness falling a fire is lighted and the cicada-seekers arrange themselves on the ground round this. They clap their hands together in unison and female cicadas come in swarms. Mr. Smythe tells me that he has seen and heard Laos doing this night after night in the Pataling district; only in his experience pieces of bamboo have always been used for clapping together instead of the hands.

GRASSHOPPERS.

Patanga succincta, *Locusta migratoria*, L., and other large short-horned grasshoppers, called by the Laos Took-ah-tanne, are eaten everywhere in Siam. The former and also a much smaller species, *Aeolopus tamulus*, Fab., were collected in my presence by a Lao at Hua Hin. They are roasted or toasted and eaten like shrimps. Siamese eat grasshoppers too.

Locusts are eaten in the Far East, in the Philippines and in the Near and Middle East where the Arabs cook them in a variety of ways. "Locusts and wild honey" are referred to in the Bible, but the most usual method of eating them is to bake them or fry them in oil with salt. When there are swarms of locusts and more than are necessary for immediate requirements, they are pounded up into a mass which is buried in the sand. Here they are sometimes left for a considerable time and the flavour is said to be not unpleasant and reminiscent of some *hors d'œuvres* dish intermediate between shrimps and anchovies. The ravens who are said in the Bible to have fed Elijah are a tribe of people who still live not far distant from Jericho. They make a kind of bread out of locusts, some cereal with a small grain and sour milk. This is usually fried in oil. It is interesting to speculate as to whether it was this kind of bread they gave to Elijah (1st Book of Kings, Chapter 17).

CRICKETS.

Gryllus testaceus, Walck.

Ching-reep-sigh : Lao name.

Brachytrypes portentosus, Licht.

Ching-reep-ong : Lao name.

Liogryllus bimaculatus, de Geer.

These three robust crickets are all eaten and are considered to have a rich taste, especially the first two, but personally I find them insipid and lacking in any flavour that I could define. In company with a Lao I dug up several of *Brachytrypes* nymphs, which have burrows nine inches deep, at Hua Hin. The head is removed and the insect is then roasted on sticks over a fire. The Siamese eat these at Patani and Hua Hin as well as the Laos.

The males of the *Liogryllus* are used for fighting by the Siamese and of *Brachytrypes* by the Malays, much money being wagered on the results.

MOLE CRICKET.

Gryllotalpa africana, Beav.

Kin-ni : Lao name.
Mang-ka-chan : Siamese name.

This light-coloured mole cricket, which occasionally flies into houses at night, is dug from its deep burrows by Laos in all districts of Siam. A Lao from Battambang (Cambodia), however, was unacquainted with it.

PRAYING MANTIS.

Hierodula sp.

Mang naap : Lao name.

Both the eggs and the adult green Mantids of this genus (of which there are several species in Siam) are eaten by the Laos at Hua Hin, and probably elsewhere also.

COCKROACHES.

Blatta orientalis, L., and the apterous *Stylophyga rhombifolia*, St., were collected in my presence by a Lao at Hua Hin. The Laos in that district and in Korat will eat cockroaches, but in most other districts they are left alone and are said to "stink." However, in all districts children appear to collect their eggs for frying.

DRAGONFLIES.

Anaz guttatus, Burm.

Mang por—this appears to be a general name for all dragonflies. This one species only is eaten in the Ubon district and there it is roasted in a dish, but the nymphs of a fat-bodied species are also eaten at Hua Hin. They are boiled and are said to taste like crayfish. In other districts dragonflies do not appear to be taken.

I was informed that in the Ubon district a lighted candle is placed in the middle of a big bowl of water and that the *Anax* dragonflies singe their wings and fall into the water. It seems doubtful to me whether they would get enough for a meal in this way, were it not for the fact that a host of other insects will be captured at the same time—termites, beetles, etc.

TERMITES.

Flying termites are known as Mang mauw, but I am not certain whether this names includes flying ants as well. The Laos set traps for them consisting of candles, which will singe their wings, surrounded by water, and in this way catch large numbers at the swarming periods. The "catch" is roasted with salt and eaten. This is by no means a bad dish. What little flavour they have is vegetable in nature, and the salt brings this out. Eaten raw they are insipid.

The queen termite is also a delicacy.

MOTHS.

To trace life-histories and breed out adults was not possible in the course of my brief visits to Siam, so practically all I am in a position to do is to say that a number of the larger Lepidopterous larvae are eaten, but that adult butterflies and moths, for some reason, are left severely alone.

Major Ladell tells me he has heard of Laos extracting *Duomitus* (= *Xyleutes*) *leuconotus* larvae from their borings in *Casuarina* trees.

Dr. A. Kerr has recently stated that the larvae of the Cossid coffee-borer, *Zeuzera coffeae,* are sent down from Ayuthia all the way to the Bangkok market. (1931, *J. Siam. Soc. Nat. Hist.* **8**, Suppl. : 217.)

His Serene Highness Prince Sithiporn told me that his cousin, the late King of Siam, was very fond of the caterpillar of *Zeuzera* which the Siamese call Duang and which feeds on *Sesbania aculeata.* The larva is roasted and eaten with salt and rice.

ANTS.

Oecophylla smaragdina, Fabr.

Mottdaang : Lao name.

This ant is one of the first insects one is bound to come across in Malaya and Siam. It is a lean yellow ant of medium size that builds a nest in shrubs after binding together a number of the leaves. The nests vary in size from a tennis ball to a football, and if interfered with in any way the ants will do their best to inflict their sharp bites. Man can be numbered amongst its enemies in Siam, for the Siamese will eat their eggs and the Laos the adults as well. They are said to have a sour taste.

A jar of water is placed immediately under the nest and then pushed upwards so that the nest is submerged. About twenty nests will make a meal for a family.

There is another and much more popular kind of ant amongst the Siamese and Laos, but I have not succeeded in getting specimens for identification. From their descriptions it is a brown ant of medium size (but the fact that they say it is variable in size may mean that they confuse more than one species). They see them walking on the ground (hence it is probably not a termite) and follow them back to a hole in the ground that marks the entrance to their subterranean nest. The nest is the size "of a big basket." The ants, their larvae and pupae are pickled in salt water, tamarind juice, ginger, onion, a little sugar and the leaf of Bai Makfut (*Citrus hystrix*).

The nests of a species of *Cremastogaster* (called Mott dam) are collected on account of their grubs which are eaten in curry in the Hua Hin district.

BEES.

There are no domesticated bees, but quite a lot of wild honey is collected and put on the market. The wax also has a considerable sale.

Xylocopa confusa, Perez.

Mang poo : Lao name.

"Blackish colour with thick yellow hair on the neck, dark purplish head and wings. Short antennae. Rounded body. Stings with tail and hurts very much. Makes holes in planks."

This is the description I wrote down from what the Laos told me at my first meeting. At the second meeting I took specimens of *X. confusa* and my diagnosis was confirmed by them and also by comparison with specimens they themselves had brought.

They knock down their bees, spike or crush their heads, pull off the wings and heads and then eat the underside of the abdomen raw—what literally they describe as the bee's breast.

Xylocopa latipes, Dr.

This is the larger purplish black carpenter bee that has done considerable damage round Bangkok by boring through the lead encasing cables.

As in the case of the last species the abdomen is bitten into from the underside and the raw goodness sipped from it.

Trichona sp.

Channaroong : Lao name.

These are very small brown bees and the Lao name embraces several species of the genus. They build nests in cracks in walls, branches, etc., and there is a small wax spout projecting from the entrance. They say the grubs and insects smell, but they eat the liquid dark honey that they can get from the nest. They say it is sweet and sour at the same time.

The wax is used by goldsmiths in doing their relief work.

Nomia sp. ?

Mang mim : Lao name.

Slightly larger than the Channaroong. Its nest is about the size of a hand with a waxy covering and honey inside. They eat the grubs as well as the honey and sell the wax.

Apis mellifica indica.

Mang peung koh : Lao name.

This bee which is like a small English honey-bee, is said to build a mud nest about 1 foot in diameter. The Laos take the nest near Hua Hin by smoking the bees with burning coconut fibre. The honey and grubs are both eaten.

Apis dorsata (?).

Mang peung : Lao name.

" Three or four stings give fever," say the Laos.

Very large crescent-shaped nests about 5 or 6 feet in diameter are fixed to the branches of tall smooth-stemmed trees of the genus *Ficus* in the northern forest districts of Siam. There may be several of these nests on a single tree. A Lao gave me the following description of the manner in which these nests are taken :—

Certain men are not stung by the bees. This immunity is passed down from father to son, and so it comes about that all the nests in a district are taken by one or a few families. On the day appointed for taking the nests prayers, ceremonies and incantations follow one another until the man is worked up to a pitch where he can feel nothing. Sacred waters are thrown over him.* Night has come, he is ready to start.

On arrival at a tree with several nests on it one final assurance that the spirits are willing must be obtained. His followers have brought a number of bamboo sticks, one end of which has been sharpened and hardened with fire. One by one these are hammered into the trunk, and if any one of them needs more than three blows to leave it fixed there, a sign has been given that the fates are not propitious. Further attempt on the bees must be postponed until another night. If, however, the test has been successful, the man is hauled up to the branch from which the nests can be reached, by means of a rope worked like a pulley. It is now time for his friends to retire to a safe distance. Hē climbs along the branch towards the nests, lights a big wad of cotton-wool or some similar material with his flint and steel and waves it wildly round the nests. As the bees come rushing out in a cloud he drops the flaming wad, and they follow it to the ground 80 or 100 feet below. Now is the time to cut down the nests and this he does as quickly as possible, not being content with an evening's work until 200 to 300 have been taken. On the honey and grubs they feast; the wax, of which there is a goodly quantity, is much in demand for candles for wats (temples) and cremation ceremonies. In the forest it fetches a price of about 1 tical per cattie, but by the time it has passed through the hands of several Chinese middlemen and, as often as not, been adulterated with pumpkin juice and paraffin wax, it costs a purchaser in Bangkok no less than 5 or 6 ticals per cattie (say 7*s*. 2*d*. to 8*s*. 2*d*. per lb.).

Apis sp. ? (possibly *A. indica*).

Mang non when : Lao name.
,, ,, won : Siamese name.

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* Cf. Hindu ceremonies. Probably what we are describing had its origin in the days when the Brahmins were in power in Siam.

This description by a Lao from Wien Chen did not enable me to identify the insect in the absence of a specimen. According to him the grubs are eaten all over Northern Siam. The bee is chocolate-coloured and about the size of the last joint of the little finger. Three stings will produce severe fevers. The nest, which is as big as a football, is made of mud and cow-dung. It hangs from the branch of a tree and a sentry is always on guard at the entrance, which is round and at the bottom of the nest. To take the nest, a man advances with a long pole and a bundle of dried grass or old cloth attached to the end. The grass or cloth is then lighted; the bees fly out and the nest is knocked down. The force of impact with the ground usually breaks the mud covering and reveals 5 to 12 circles of cells.

The grubs are all picked out and fried or eaten in curry. A favourite dish is as follows :—In coconut milk put onion, pepper, Takrie (a lemon glass, *Cymbogon citratus*) and Bai Makrut leaves (*Citrus hystrix*). Wrap them in linen, steam them, and then add them to rice.

WASPS.

Eumenes petiolata, Fab.

The grubs of this large yellow and brown thin-waisted Eumenid are called Mang taan at Hua Hin, where they are fried for food.

Vespa cincta, Fab.

Tua thor : Lao name.

This hornet occurs throughout the whole of Siam, and its grubs are eaten in Southern (Hua Hin), Western (Suphan), Eastern (Battambang) and Northern Siam (Chieng Rai). The broad orange stripe across its abdomen renders it conspicuous, and the Laos of North Siam say that to be stung by one of these makes one's hair go white. The statement that a few stings are liable to cause death is authentic, I believe, which makes the taking of their nests all the more praiseworthy. The nests are in hollow trees and the wasps are destroyed by fire and smoke. When all is quiet the nest is pulled out and the grubs and adults are both fried with a little salt, the legs and head having been removed from the grown wasps. At Hua Hin, and perhaps elsewhere, the Siamese as well as the Laos eat the grubs of this wasp.

MEDICINAL INSECTS, ETC.

Some creatures are eaten not for their taste or nutritive value, but on account of their medicinal properties. Here my list is probably far from complete.

Earthworms. These are used for smallpox. They soak the worms in a dish of water and bathe the patient in the liquid. This is said to have a cooling effect. The worms are then roasted, powdered, mixed with young coconut water and then drunk ! This treatment is said to hasten the course of the disease and to reduce mortality from nearly 100% to 25%.

The Siamese have a somewhat similar cure. The top is cut off a young coconut, the worms are put inside and roasted. The liquid is then drained off and drunk.

Dung beetle. There is a very large black dung beetle belonging to the genus *Heliocopris* that is found in Northern and Eastern Siam. A Lao from Ubon stated that it is taken for diarrhœa and dysentery. The beetle is roasted, pounded up and then added to water in which a little powdered lime (or limestone ?) has been placed, and a little saffron. The whole is stirred up and swallowed. The Lao name for the beetle is Mang chu chee, and it is also highly prized for food.

Carpenter bee. One with a yellow thorax and black body (*Xylocopa confusa*) is used by Laos in Battambang (Cambodia) for children's throats when they are sore. The bee is roasted, pounded up, added to milk and then applied to the throat with a finger.

Centipedes. Some, called by the Laos Tua takhap, exceed 6 inches in length, and these have a poisonous bite.

According to one account they are roasted and given to children suffering from " thinness and swollen belly," possibly hookworm or malaria.

In Ubon they pound it up after roasting it, soak it in alcohol and the juice of Borapet (*Tinospora rumphii*) as a stimulant.

THE BRITISH TACHINIDAE (DIPTERA). FIRST SUPPLEMENT

By Colbran J. Wainwright. J.M.R.

[Read June 1st, 1932.]

With Nineteen Text-figures.

Since the publication in the volume of these *Transactions* for 1928 of my paper upon the British Tachinidae a dozen or more additional species have already been discovered, and the purpose of this paper is to record and describe those species, and at the same time add some further information regarding some of the earlier known ones.

Echinomyia, Dumèr.

Mr. E. Rivenhall Goffe kindly gave me a specimen which I have identified as (*Eudoromyia*) *magnicornis*, Zett., which was believed to have been taken in Devonshire. It came out of a small collection from the neighbourhood of Plymouth, which owing to the circumstances in which it was made was unlikely to have contained any foreign insects and seemed to consist entirely of locally caught ones. Unfortunately, however, it was not labelled, so that its actual history must remain uncertain; moreover, it is a female, and this is one of the many cases where one does require the male for certain identification, so that it cannot be regarded as a British species without further confirmation.

Ernestia, R.-D. (Figs. 1–3.*)

The small subgenus *Panzeria* has been responsible for a number of specific names, but the tendency has been to regard all as synonyms of the one common and widely distributed species usually known as *rudis*, Fall., and Bezzi in the Katalog (8) so treated them. *E. nielseni*, Villen., had long been regarded by me as a distinct species before it was finally described and named by Villeneuve and Nielsen in 1917, and Stein (24) thought that he could distinguish a third species to which he applied Meigen's old name *vagans*, but he was not followed.

During 1931 I gave some attention to the genus in the hope of meeting with Stein's species, and took a large number of specimens without success, but at length detected an old example in my own collection taken on June 3rd, 1903, at Tan-y-bwlch, N. Wales, in company with normal *rudis*, Fall., which exhibited the external characters of *vagans* teste Stein; namely, three broad clearly defined black thoracal stripes, three well-developed pairs of praesutural acrostichals, and the white tomentum of the abdomen forming more clearly defined bands than in *rudis*. Having already found undoubted *rudis* exhibiting all these characters in some degree, though not all together or so distinct, and as already mentioned, having taken undoubted *rudis* at the same time and place, I was not at first inclined to attach much importance to this specimen, but it was placed in the relaxing tin, the genitalia drawn out, and then the difference stood revealed. The mesolobe (= forceps, or central clasper) as seen directly from below is quite distinct in the three species of the genus as follows :—

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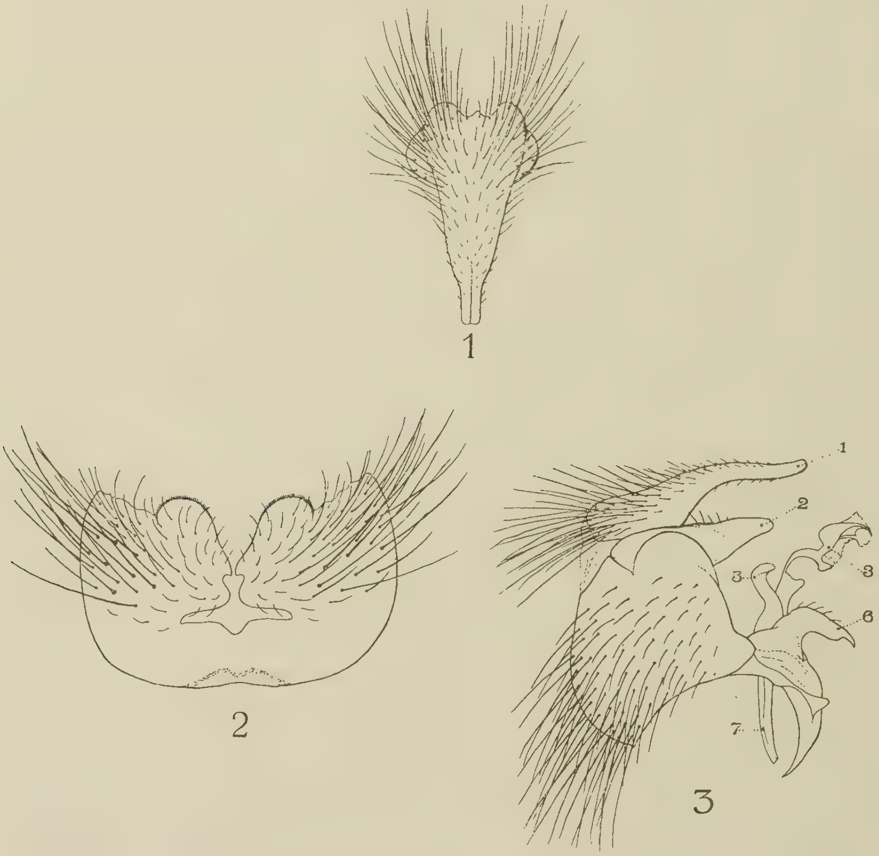
* The numbering of the structural details has the same meaning throughout. 1, Mesolobe; 2, paralobe; 3, penis; 4, aedeagal style; 5, anterior process; 6, posterior process; 7, apodeme of penis.

Flat wide and spatulate, slightly widened not far from the end, and then tapering to a sharp point; very rugose or coarsely punctate, and in its basal portion covered with dense rather long black hairs . . . . . *rudis*, Fall.
Also sharply pointed but much narrower, slightly keeled, regularly tapered from base to tip, much less punctate and rather shiny, and with short pubescence only on the basal portion . . . . *nielseni*, Vill.
Flat as in *rudis*, not keeled, regularly but not rapidly tapered from the base to a broad blunt end, the end slightly lobed, and about equal in width to half that of the mesolobe in its central part; not very rugose but rather smooth, and I think there are only short hairs at the base as in *nielseni*. (See figs. 1–3) . . . . *vagans*, Mg.



Figs. 1–3.—*Ernestia* (*Panzeria*) *vagans*, fig. 1, mesolobe from above; fig. 2, apical abdominal sternite; fig. 3, profile of genitalia.

My specimen of *vagans* having been damp, the hairs at the base have become somewhat matted so that I cannot see them well enough to be sure if they are as described.

These differences in the form of the mesolobe taken in conjunction with the external characters already mentioned seem clearly to establish *vagans* as a good species, and I think I see evidence of other distinctions in the form of the paralobes (side claspers), etc., but they are not sufficiently evident in my specimen. Although the species may be detected from its external characters, the genitalia must be examined for certain identification; I have *rudis* with three broad thoracal stripes, and others with two praesutural acrostichals on one side and three on the other, though none with all the characters of *vagans* clearly developed in combination. Mr. J. E. Collin has kindly examined his specimens of *Ernestia* and finds that he has *E. vagans*, Darenth (Kent), 13.v.68; Abbots Wood (Sussex), 17.v.73; Lyndhurst (Hants), 29.v.97; and one taken by G. C. Bignell probably near Plymouth.

I have seen 2 ♂♂ of *Ernestia connivens*, Zett., taken at St. Ives, Cornwall, by Rev. A. Thornley; and myself took a pair of *E. vivida*, Zett., at Aston Rowant, Bucks, 2.viii.27, but am still doubtful about the value of these two species.

Exorista, Mg.

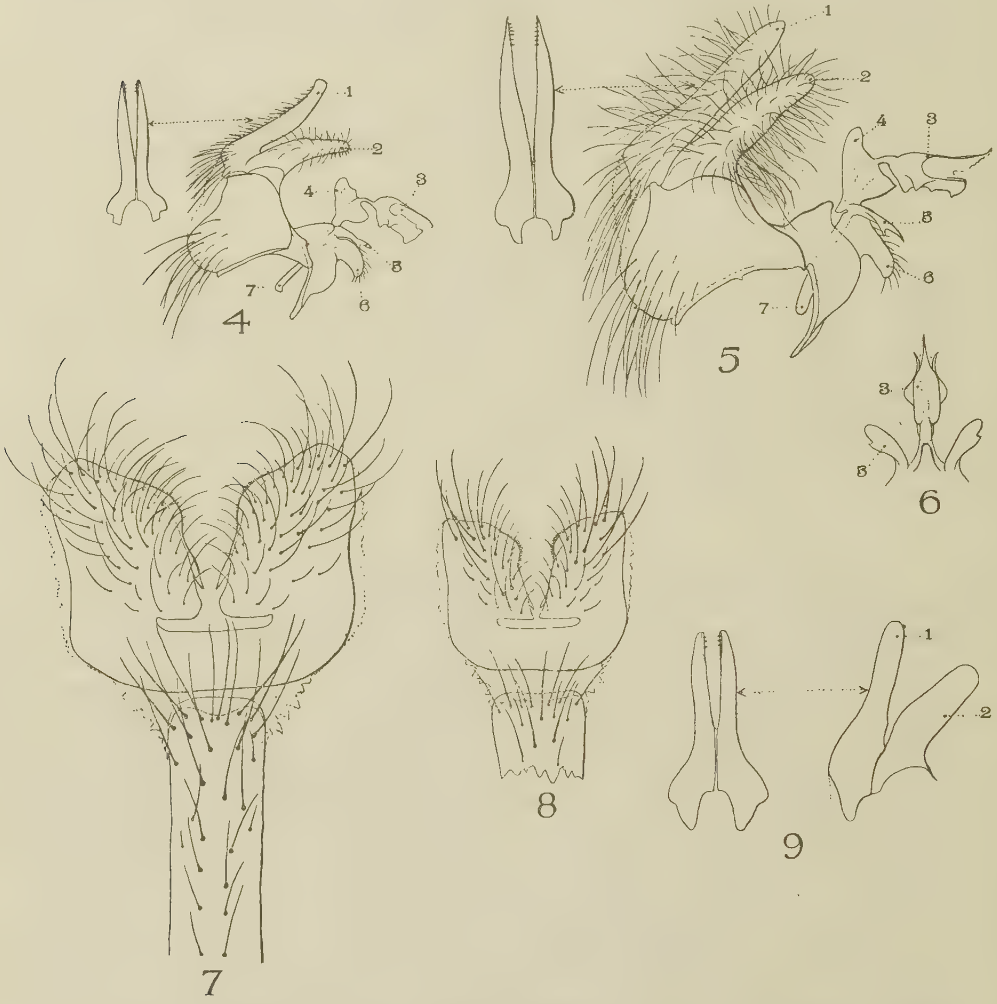
In my table of the species of this genus and its allies, *westermanni*, Zett., has been placed somewhat incorrectly. Its frons is scarcely of eye-width, and so it might run to 2 instead of to 7; and it has only one pair of praeverticals in the male, and so should have been bracketed with *hortulana*, Mg., at 21 instead of being carried to 22. Further, in an examination of additional specimens I find that the third joint of the antennae may be not more than four times the length of the second; finally, its face as seen in profile should have been described as convex not concave. The Rev. A. Thornley took two males at St. Ives, Cornwall, in 1929 and a female at Dunmire.

Masicera, Macq.

I included this genus in the tables in my paper and referred to the two species because although I had never seen British specimens, yet they had been so persistently recorded in older writings that it seemed likely they might occur. Recently, in the course of an examination of the TACHINIDAE in the Tring Museum, I found two old specimens, which may even possibly be the actual ones upon the authority of which the species found their way into our lists. One was an undoubted ♂ of *pratensis*, Mg., a carded specimen labelled " From *Saturnia carpini*, Mr. Fenn." Unfortunately there was no indication of place of origin, so that one cannot be sure that it was British, but it seems at least probable. The other, a ♀ specimen carded in the same style and labelled in same handwriting " From *Pieris brassicae*, Mr. Winkley," seemed to me to be a ♀ specimen of *silvatica*, Fall., but the two species are not easily separable in this sex. As it is from a different host and collector, there is no reason to assume that it is conspecific with the ♂. It is curious that these two hosts happen to be the ones quoted by Meade (6) in his papers, and it is certainly possible that they are the actual specimens Meade saw: if so, it is important to remember that the place of origin is unknown.

Meigenia, R.-D. (Figs. 4–9.)

In my former paper I dealt at length with the difficulty of distinguishing the two well-known common species of this genus, *bisignata*, Mg., and *floralis*, Mg., and expressed myself as dissatisfied with all the supposed characters. I mentioned also that Stein (24) (who, however, was really accepting Pandellé's views (19)) had amalgamated the two and treated them as representing a single variable species under the name *mutabilis*, Fall. In spite of the difficulties I could not bring myself to believe that insects so very different as the small, dark, heavily marked specimens which I knew as *floralis* and the larger, paler, less marked individuals that represented *bisignata* were really conspecific, although there were unsettling intermediates tending to approach *bisignata* in size and *floralis* in appearance, and I decided that it was a case to be put to the test of the genitalia.



Figs. 4–9.—fig. 4, *Meigenia bisignata*, profile of genitalia and outline of mesolobe seen from above; fig. 5, *M. pilosa*, do., do.; fig. 6, *M. pilosa*, penis and anterior appendages seen from above; fig. 7, *M. pilosa*, apical abdominal sternite; fig. 8, *M. bisignata*, do., do.; fig. 9, *M. majuscula*, outline of genital forceps.

Accordingly when on Farley Downs in August 1931 I collected a small series with which to make a commencement, and drew out the genitalia of them all. On examination they proved to be a most interesting lot. There are nine males and three females and they constitute a fairly even series, all of about the same size and appearance, and belonging to that group of puzzling intermediates referred to above; being large—fully 6 mm. long—perhaps a little smaller on the average than typical *bisignata*, but as large as many individuals—and on the other hand nearer in coloration and pattern to *floralis*. The value and interest of the series lay in the fact that all these males possessed genital claspers (mesolobes) of a type that I had not previously observed. (See figs. 5–6.) Once more genital characters had apparently solved our difficulties; for on examining my old material I found that practically all the old uncertain specimens, the intermediates which had proved my stumbling blocks, possessed this type of clasper, and none either of the small *floralis* or large *bisignata* types. Ultimately I relaxed and examined the genitalia of over ninety males and no longer had any difficulty in separating them into three well-characterised groups. By a curious chance the mesolobes of the small dark specimens and the large light-coloured ones are so much alike that I have not been able so far to detect any differences (see fig. 1), but when one has removed all the specimens with the other type of mesolobe, one finds that all the intermediates have gone, and one is left with two groups which seem to me abundantly distinct on external characters, and to constitute two very different species.

Before describing the three species, one must decide what names are to be used. It so happens that Baranoff (1927, *Encycl. Ent.* B, II, "Diptera," 4: 43, 44), accepting the single-species idea, illustrated four types of genitalia which he had found amongst Serbian specimens and gave them subspecific names. Amongst them was our new form from Farley which he called *mutabilis pilosa*. I sent him one of my specimens to compare with his, and he reports that the two are identical. As I am definitely of opinion that this form should be treated as a species, and Baranoff's clear drawing makes identification certain, I propose to adopt his name and raise it to specific rank.

It is more difficult, however, to decide what names to use for the other two. I sent specimens of each also to Baranoff, and he reports that our *bisignata* is the one he has called *mutabilis vulgaris*, and that the small species that we have been calling *floralis* is quite unknown to him; he not only has not found it in Serbia, but has never seen it in any other collection. This might mean that the species known to Pandellé, Stein, and others as *mutabilis* was usually *bisignata* and possibly that we ought to use *mutabilis* for that species; but reference to Fallen's description of *mutabilis* has convinced me that he was not describing what we have known as *bisignata*, Mg., and as that name can apply to no other species I propose to continue to use it.

Floralis, Fall., is apparently the species we call *Nemorilla floralis* and not a *Meigenia* at all, so that some other name must be found for our small species. Fallen in Dipt. Suecica very distinctly says that his *mutabilis* is one of the smallest species in his genus *Tachina*, which would not be correct to say of *bisignata*, but does fit the insect we have hitherto known as *floralis*; moreover, the general description and especially the references to the abdominal markings further indicates the same species, to which therefore I propose that the name *mutabilis* shall be restricted.

The following rough key to the three species may perhaps enable them to be recognised :—

1. Genital claspers seen in profile with both mesolobe and paralobes quite straight, and not diverging from one another at their distal ends; the paralobes thick and strongly wedge-shaped, tapering to a somewhat blunt point; the whole bearing many long hairs giving them a very hairy appearance. (See figs. 5–7) . . . . *pilosa*, Baranoff.

Genital claspers as seen in profile not quite straight, the paralobes being curved inwards, and the mesolobe outwards, so that they diverge at their distal ends; the paralobes not wedge-shaped but parallel-sided and thinner, with rounded ends, the mesolobe with a slightly thickened tip; they are clothed with hairs which, however, are short and inconspicuous and do not suggest hairiness . . . . 2.

2. Smaller species, variable in size but rarely exceeding 5 mm. in length (the largest about the size of the smallest of the other two species); the male very dark looking owing to the extension of the dark markings on thorax and abdomen; the usual pairs of dark dentate markings on the hind margins of the segments, characteristic of the genus, strongly developed on segments 2 and 3 and usually coalescing with the dark central line to form transverse bands with dentate fore margins: the dark markings also take up almost the whole disc of the thorax *mutabilis*, Fall. (= *floralis*, Wainw. 1928).
3. Larger species, very variable in size and sometimes not much over 5 mm. in length but usually 6 or 7 mm. and even 8 mm. long; the male much lighter and greyer looking, owing chiefly to the reduction of the dark markings; the spots on the abdomen usually reduced to one pair on the 2nd segment only, and those well separated; sometimes the markings are almost completely absent, and sometimes there is a pair on the 3rd segment also, but never strongly developed as in *mutabilis*, never coalescing or band-like. (See figs. 4 and 8) . . . . . *bisignata*, Mg.

The new species *pilosa* is intermediate throughout, in size more nearly approaching *bisignata*, being between 6 mm. and 7 mm. long; and more resembling *mutabilis* in colour and markings, bearing conspicuous dark abdominal markings on segments 2 and 3 though less developed on the 3rd, and not tending to coalesce into dark bands. Judging by my series it is a more constant species than either of the others, less variable either in size or markings.

Regarding the other two species, Pandellé himself when amalgamating them, remarked that it was the larger specimens which showed the characters of *bisignata*, and it seems improbable that mere variation should lead to this association of large size with reduced markings and small size with highly developed markings. As is so often the case the females are less easily identified, but the smaller ones which on size alone would be referable to *mutabilis* seem always to have fairly distinct spots on the 3rd segment and generally to show a greater development of the markings than in the larger specimens. Lacking the assistance of the genitalia I have failed to separate *bisignata* from *pilosa* with any certainty, perhaps in *bisignata* the frontalia is narrower than the orbits, and in *pilosa* wider and darker, but I am not sure. *Pilosa* as I know it seems to be associated with calcareous soils. It was on chalk downs that it was detected, and besides Farley Downs I have it also from Aston Rowant, Wormsley, and Princes Risborough, all on the Chilterns, and from Aigle in the Rhone Valley, and Vernet-les-Bains, and Argelès-Gazost in the Pyrenees, all of which I think are in limestone districts; but I also have it from Rhayader in Radnorshire; Stoke Wood, Herefordshire; Tubney near Oxford; and Criccieth in N. Wales, none of which I believe can be considered to have calcareous soils.

My friend Dr. Villeneuve does not consider that very closely allied forms like the three with which we are dealing, and incidentally also like the *Tachina rustica* group dealt with later on in this paper, should be regarded as full species in the ordinary acceptation of the term, and in the Linnaean sense, and refers to them as "petites espèces," "espèces élémentaires" or "jordanons." He would perhaps call them subspecies, but would like to have them regarded as belonging to species complexes, using the trinomial system in referring to them; for example, following Baranoff in the present case, treating *pilosa* as a member of the *mutabilis* complex and calling it *Meigenia mutabilis pilosa.*

If one has any real belief in the evolution of species, as I certainly have, then one must recognise that there would be found every stage, from new segregations resulting in new breaks in the continuity of species with no visible differences, so that the discontinuity may remain unsuspected, up to long since fully developed species where all the intermediates or allied forms have disappeared and the species stand alone, an infinite range of fine differences of degree in species values; indeed possibly scarcely two would be precisely equal. Where, however, it is possible to detect and define a definite segregated entity, even if its distinctions from its allies are not very evident to our senses, it seems to me that it requires a name by which it can be known, permitting of reference, and it matters very little whether, having so named it, we regard it as a species, subspecies, or variation.

On the other hand, I am strongly in agreement with those who protest against the practice of giving names to the variations and aberrations which occur almost universally within the limits of continuous aggregations, and would like to have all such variations from the normal indicated by a set system without giving names. I am even more definitely opposed to the method developed in certain quarters of giving racial or subspecific names to mere family parties which may meet and mingle with other family parties within the same species entity, merely because it may be possible to detect inequality in the variational tendencies, and would like it to be the rule that all such cases should be referred to by place names only. In fact, I would make physiological discontinuity the test of a species.

In a case like the present one, the very distinctly different claspers of *pilosa* indicate to my mind a definite entity, a discontinuity or segregation of a form, and being detected it should be named as such. It is not *mutabilis* or *bisignata*; it is another thing and should be known by its own name.

Incidentally I may be permitted, perhaps, again to refer to a matter I mentioned in my former paper, namely the probability of the existence of biological species: species which are completely separated through mode of life, choice of food, dates, etc., and that may even have developed different physiological reactions, instincts, etc., and yet are absolutely indistinguishable to the human eye. One never can tell that species which we separate with difficulty may not be filling very distinct places in the economy of nature. The genus *Lucilia* affords a case in point; although only just separable by our standards, yet one finds one of these closely allied species, namely *bufonivora*, Mon., having developed quite remarkable special habits of its own, and it appears to be *sericata*, Mg., only which has become a pest to sheep. That being so, if we *can* separate two species even on fine genitalic characters, it does not do to assume that their whole lives and existence must run on equally close lines; so that again I say, if we can clearly define a distinct entity we should give it a name, and I care little whether it is called a species or something else.

Viviania, Rond.

The character given in section 57 of my table is poor; the difference is not sufficiently distinct, but the following will help :—

Abdomen with discal macrochaetae; claws of the ♂ long . . . . *Meigenia.*
Abdomen without discal macrochaetae, claws of the ♂ short, only about length of the last tarsal joint . . . . *Viviania.*

Graphogaster, Rond.

A female fly taken by Col. C. G. Nurse at Tunbridge Wells in August 1924 has been identified by me as *Graphogaster brunnescens*, Villen. It is a very distinct little species quite unlike anything previously known as British, and possessing a combination of characters which should make its identification easy. It is very small, only about 4 mm. long, with a very rotund almost globular abdomen, and is covered with a brownish-grey tomentum giving it a very grey appearance. It has a long stalk to the 1st posterior wing-cell; the hinder cross-vein is situated midway between the discal cross-vein and the bending of the 4th longitudinal; the antennae have the 3rd joint only a little longer than the 2nd, with a bare arista; abdomen with discal macrochaetae; thorax with indistinct dark markings; 1st segment of abdomen dark, 2nd with a dark hind margin and 3rd also a very slight one; all the rest pale grey with dark bases to the setae; legs, antennae, palpi, and frontalia all black; D.C.3; long crossed apical scutellars. In my key it runs down to 54, but is easily distinguished from *Melanophora* and *Plesina* by characters quoted above.

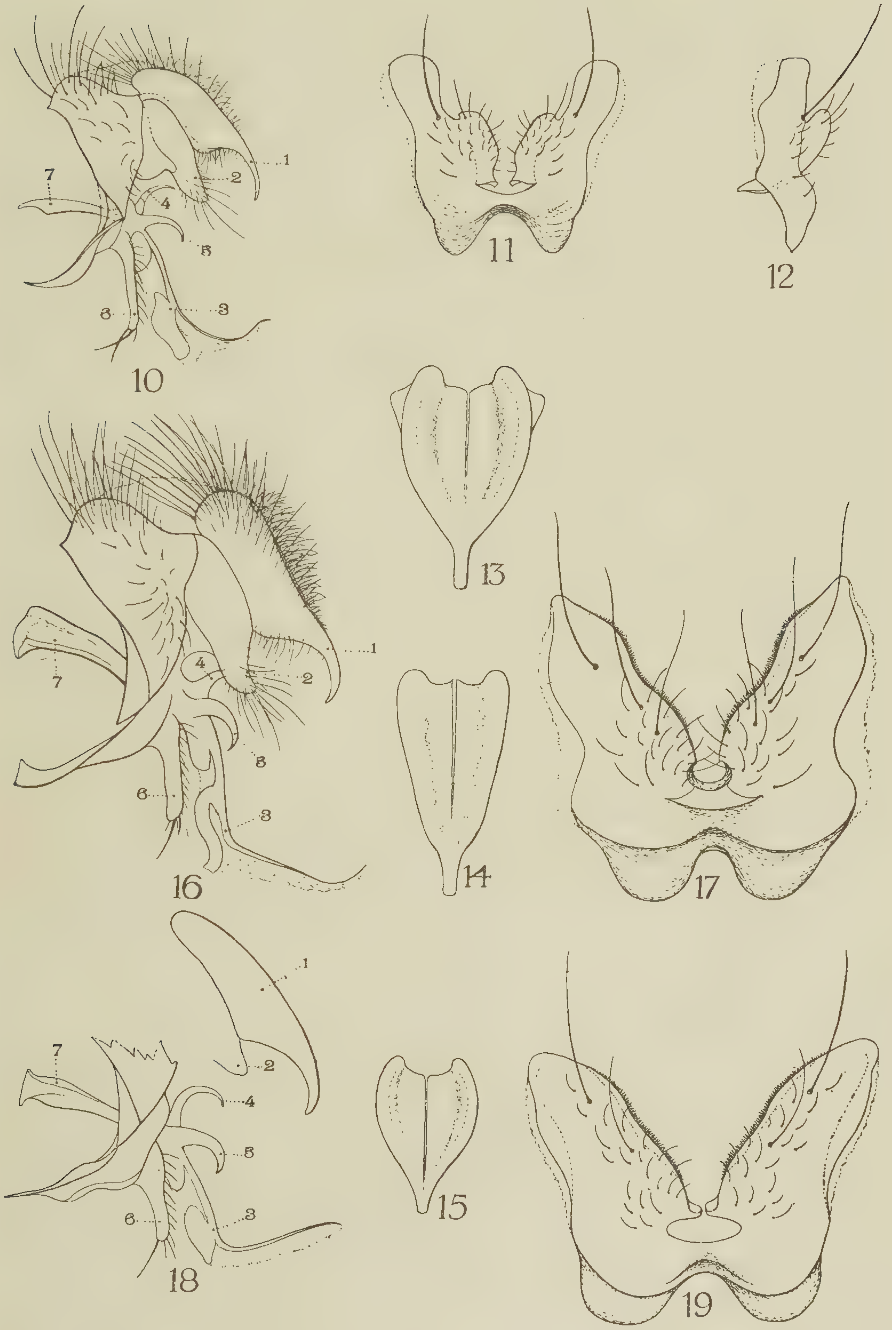
Tachina, Mg. (Figs. 10–19.)

The species of this genus remain uncertain, but there are one or two facts that should be placed on record.

On Farley Downs, Hants, in 1931 I took three males of *erucarum*, Rond. Previously this form had only been represented in my collection by females, and in common with other dipterists I had regarded them as nothing more than individuals of the variable *rustica*, Mg., in which the abdominal discals failed. The Farley males were set with the genitalia drawn out, and the claspers could therefore be compared with those of *rustica* and differences were discovered sufficient to make me feel sure that these specimens at least represented a distinct species. Both species had the characteristic and rather remarkable grooved external surface of the mesolobe with its double fringe of red-coloured hairs, but the outer form of that organ as seen from below differed materially. In typical *rustica* (see figs. 13 and 16) it is rounded in outline, the sides curving outwards from the base and back towards the apex in very full curves, and the whole organ is wide in proportion to its length, the width being nearly equal to ⅔rds of the length. In *erucarum* (see figs. 14 and 18) the sides scarcely curve outwards from the base, are nearly straight, so that the whole clasper tapers fairly directly to the apex, and it is as a whole narrow in proportion to its length, the width being just about equal to half the length. There are other slight differences not easily conveyed without drawings, but the above will be sufficient to enable the two species to be separated. This genital character in combination with the complete absence of abdominal discals, and the 3 D.C. sufficiently indicate, I think, a good species. The absence of the discal setae alone is unreliable as a character as *rustica* does undoubtedly vary in that respect.

Whether this form is actually the one Rondani had before him when he erected his *erucarum* is a question I cannot decide, and only dissection of the type specimen could settle it; it may be therefore that the Farley species is not entitled to the name, but I am using it in the meantime.

On Farley Downs also Mr. Collin and I found what seemed like a remarkably small race of *rustica*, Mg. We found it first in August 1930 and again in 1931, and its extremely small size alone made us feel that it might be something more than a dwarf form of the common species; careful examination, however,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FIGS. 10–19.—fig. 10, *Tachina minor*, profile of genitalia; fig. 11, do., apical abdominal sternite; fig. 12, do., do., side view; fig. 13, *T. rustica*, outline of mesolobe from above; fig. 14, *T. erucarum*, do.; fig. 15, *T. minor*, do.; fig. 16, *T. rustica*, profile of genitalia; fig. 17, do., apical abdominal sternite; fig. 18, *T. erucarum*, profile outline of part of genitalia; fig. 19, do., apical abdominal sternite.

revealed very little in the way of other distinctions. The frontal setae which descend on to the genae seem reduced in number, being only 2, 3, or 4 at most; the abdominal discals seem weakly developed, but reduced chaetotaxy is what one expects in undersized specimens. An examination of the mesolobe (see figs. 11–12) was not much more helpful: in outline it is almost exactly the same as in *rustica*, but in profile there seem slight differences. Seen thus, in *rustica* there is a dip in the middle of the curve from base to apex, whilst in both *erucarum* and this small form the curve is continuous: also the final curved hook-like apex seems thinner and the inside curve (still as seen in profile) to be more extended towards the base.

Having directed Mr. Collin's attention to the above facts, he with his usual thoroughness proceeded to dissect out the genitalia of all the three species and to make careful mounts and drawings of the same; and he discovered a character in the apical sternite in some of the small specimens which seems to support the notion that they represent a distinct species. This sternite in common with that of most TACHINIDAE is deeply cleft, making it roughly speaking V-shaped. In typical *rustica* the inside edges of this cleft are approximately straight and simple; they are waved somewhat, but not conspicuously so; whilst in these small individuals there is about the middle a conspicuous tooth-like projection which not merely breaks the line of the edge of the V, but also projects downwards so as to appear to be standing up from the sternite. Unfortunately this sternite is not visible in all the specimens, and it does not seem possible to examine it in such cases without dissection. A further character that Mr. Collin's drawings revealed is that the anterior pair of hook-like processes are long and slender in the new form, shorter and stouter in *rustica*, and the oedeagus is a little different, though it would require the drawings to illustrate their distinctions.*

True *rustica* varies greatly in size, and I have some small specimens though none so small as this new form, the smallest of which are only 5 mm. long. Mr. Collin tells me, however, that he has some from Upton Broad, Norfolk, which are quite as small as those from Farley and which he regarded as identical with them until he examined the genitalia, so that size is not a perfect guide; nevertheless size is important as the Farley ones seem consistently small as well as possessing the genital characters. In all the circumstances I think the form needs a name whether it be regarded as a species, a subspecies, or local variety, and I propose **minor**, n., and am making a ♂ specimen in my collection labelled " Farley Downs, 1.viii.31 " the type.

Hitherto all species of *Tachina* with the red brush of hairs on the genitalia have been regarded *ipso facto* as *rustica*, Fall., but if my conclusions are correct there is a group of closely allied species involved, such as my friend Dr. Villeneuve would regard as a species complex, and it will be desirable to watch for evidence of other distinct forms. The genitalia of *rustica* are so different from those of *larvarum*, L., that there may be justification for retaining *Chaetotachina* as a subgenus, if not a full genus, but there can be none whatever for *Microtachina* erected by Mik on chaetotaxial characters alone; for, as shown, *rustica* and *erucarum* constitute a pair of species which are very closely allied and which would have to be bracketed together in any division of genera however hair-splitting.

I have seen a male *Tachina* taken by Dr. F. H. Haines at Linwood in the

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* Mr. J. E. Collin has since made finished drawings of the genitalia of all three species of *Tachina* referred to above, and they have been reproduced in figs. 10–19. The differences mentioned are clearly shown.

New Forest which I think represents another species of the *larvarum* group, but am anxious to obtain more material before dealing with it. Externally it is characterised by the possession of 4 D.C. no abdominal discals, and a black scutellum; but if I am right, it will be the genitalia that will prove the deciding factor.

Stomatomyia, B. & B.

In 1929 when collecting with Mr. J. E. Collin amongst the sandhills of the Norfolk coast we met with *S. acuminata*, Rond., which had previously been known only from Felixstowe. It is evidently at home amongst these sandhills and possibly not uncommon.

Germaria, R.-D.

G. angustata, Zett., was also taken on the Norfolk coast at the same time and place as the *Stomatomyia*. The single previously known British specimen, taken by Mr. Verrall, was labelled Martham; but as I felt sure that it would prove to be a sandhill species, I formed the opinion that it would be more likely to occur on the extensive sandhills of the neighbouring coast than at Martham itself, and Mr. J. E. Collin and I therefore paid a special visit to Winterton in August 1929 in search of the species. On that occasion, in poor weather, one specimen only was obtained, and that fell to Mr. Collin's net. A day or two later I caught a second specimen, in similar conditions, at Blakeney Point further north; and in 1930, on a more favourable day, Mr. Collin went again to Winterton and took two pairs.

Gonia, Mg.

G. capitata, Deg., may now be regarded definitely as a British insect. When examining Mr. E. Rivenhall Goffe's collection, I found two females of *Gonia* taken by him on the neighbouring Farley Downs on August 13th and 18th, 1929, which I am satisfied are true examples of this species. When collecting in the same locality in August last year, 1931, Mr. Collin and I met with it and two more females were obtained by Mr. Collin.

Possibly therefore it is one of the many interesting species that seem attached to that type of downland, and one may expect to find it in other similar localities.

Actia, R.-D.

I have seen 2 ♀♀ of *nudibasis*, Stein, from Suffolk, bred from *Rhyacionia* (*Evetria*) *buoliana*, Schiff., by Dr. W. H. Thorpe. *Antennalis*, Rond., has turned up from several localities and seems likely to prove not an uncommon species.

Trichoparia, B. & B.

Mr. E. Rivenhall Goffe took a single ♀ specimen of *blanda*, Fall., on Ashley Downs, Hants, 4.viii.1929, thus confirming it as a British species. By Mr. Goffe's kindness the specimen is now in my collection.

Loewia, Egger.

L. phaeoptera, Mg., and *L. foeda*, Mg., are very closely allied. In addition to the characters given in my paper it may be useful to add :—

Three postsutural dorsocentral setae; three setae at the base of the third longitudinal vein . . . . *phaeoptera*, Mg.
Four dorsocentrals; about six setae on third vein . . . . . . *foeda*, Mg.

Zophomyia, Macq.

Of the rare species *Z. temula*, Scop., I have since seen a ♂ taken by Mr. R. C. Bradley at Selsley near Stroud, Glos., 15.v.94; one taken by Mr. E. Rivenhall Goffe at Calshot, 26.v.1929; and in June 1931 I found it in a meadow near Bewdley and obtained several specimens, so that it may prove widely distributed.

Leskia, R.-D.

Leskia aurea, Fall., is a very distinct species which must be added to our list on the strength of a female specimen taken by Mr. E. Rivenhall Goffe in Hampshire. Unfortunately the specimen was unlabelled, but Mr. Goffe remembered it well and said that it had remained unlabelled because, owing to a mishap, he had got two or three lots of his captures mixed up, and he was not sure from which locality this came, but in either case it was from the neighbourhood of Romsey, in 1929. Meade (6) certainly included it in his "Annotated List," but as I had never seen a British specimen it was omitted from my previous paper. It is very closely allied to *Myiobia*, to which genus it would run in my tables at 29; and is distinguished sufficiently from the fact that it is entirely yellow excepting for a little darkening on the dorsum of the thorax, and black tarsi.

Ocyptera, Latr.

Mr. Collin and I found *interrupta*, Mg., on Hengistbury Head in August 1931, and each obtained several specimens.

Trixa, Mg.

Villeneuve (1928, *Konowia*, **7** : 303) has pointed out that our species is not the true *alpina*, Mg., and that it should be called *caerulescens*, Mg.

Prosena, St. Farg.

Luculliana, Rond., occurs not uncommonly on Farley Downs in Hants, and uniformly presents the characters referred to in my paper as distinguishing it from *sybarita*, F. *P. sybarita*, F., is not uncommon off the downland in the immediate neighbourhood, in the New Forest, for instance, but is equally constant in its coloration.

Myiocera, R.-D.

The ♀♀ have no marginal macrochaetae on the first visible segment.

Rhinomorinia, B. & B.

R. puberula, Zett. There is in the British Museum one male of this species from Nethy Bridge, Inverness-shire, 13.vii.1905, and a female from Brodie, Elgin, 5.vi.1905, both taken by Col. Yerbury. Miss Aubertin kindly gave me an opportunity of examining these two specimens.

Phyto, R.-D.

P. melanocephala, Mg., and *P.* (*Styloneuria*) *discrepans*, Pand., are very much alike in the female sex. The following distinctions may be useful :—

Frontalia, wider than the frontorbital, nearly twice as wide; palpi yellow; usually weak marginals on 2nd visible abdominal segment, and weak discals on 3rd . . . . *melanocephala*, Mg.

Frontalia at most as wide as one orbit, usually narrower; palpi black; never any marginal macrochaetae on the 2nd abdominal segment and usually no discals on the 3rd . . . . *discrepans*, Pand.

Sarcophaga, Mg.

In my paper were recorded 25 species belonging to this genus, excluding *Agria mamillata*, Pand., and I noted that there were probably others yet to be discovered in this country. Already in this brief period three more names have to be added to the list.

S. tuberosa, Pand., in the type has black apical segments; there is, however, a variety with the second genital segment red, *exuberans*, Pand., and it is this form which has now been taken here. In my key it runs down to 6, where, as it possesses praescutellary acrostichal macrochaetae, it has to be compared especially with *falculata*, Pand., and is distinguished as follows :—

No setae on hind margin of 2nd genital segment; genital clasper (mesolobe), seen in profile, curved and tapered in sickle-like form *tuberosa* var. *exuberans*, Pand.

Possessing a row of short setae on hind margin of 2nd genital segment; clasper in profile shows a sharp dip in the upper edge near to the tip, which is abruptly tapered and beak-like . . . . . . *falculata*, Pand.

The form with no red on the genitalia will probably also be found here. Belonging to the *carnaria*, L., group, it runs in my key to 15, where it has to be compared with *teretirostris*, Pand., and another addition to the British list, *similis*, Pand.

All three of these species differ from *carnaria*, L., and *vicina*, Villen., in possessing no marginal setae on the 2nd abdominal segment, but are very like one another in general appearance and characteristics, and are most easily identified by the genitalia, which, however, can only be fully understood from drawings. The following short key may, however, enable them to be separated :—

Hind tibiae with rows of long fringe-like hairs on both sides; genital clasper (the mesolobe) somewhat curved inwards, with a thin tip which tends to be bent in S-like form; the aedeagus has two pairs of subterminal processes which cross one another below, and above and beyond them is a short sharp tip . . . . *tuberosa*, Pand.

Hind tibiae with long fringe-like hairs on postero-inferior aspect only, there are hairs and bristles on the antero-inferior aspects, but not fringe-like, and not long like the others; genital clasper nearly straight, thick, with slight curved tip only; aedeagus has similar paired and crossed subterminal processes to *tuberosa*, but above and beyond them is a long blunt end piece; no brush-like hairs on 5th ventral segment . . *teretirostris*, Pand.

Hind tibiae with fringe on postero-inferior aspect only as in *teretirostris*; genital clasper thin, regularly tapered and strongly curved inwards; aedeagus in the basal portion below with a long curved thorn-like process of which there is no sign in the other two species; 5th ventral segment with strong brush-like hairs on the inner edges . . . . *similis*, Pand.

S. teretirostris is already well known; it is one of our commoner species. Of *tuberosa*, var. *exuberans*, Mr. J. E. Collin captured one male at Blakeney Point on August 9th, 1929, and another at the same locality on June 10th, 1930; and of *similis*, Pand., I took a single one at Arne, Poole Harbour, Dorset, on August 3rd, 1930.

The third addition *hirticrus*, Pand., we owe to the Rev. A. Thornley, who discovered it at St. Ives, Cornwall, and has already recorded it in 1931, *Ent. Mon. Mag.*, **67** : 91. It seems to be a common species in that neighbourhood.

In my key it runs to 19; or possibly, on account of occasionally possessing somewhat developed praesutural acrostichals, to 25; but it is a very distinct species, not much like any other of our fauna. It is a hairy insect, with a tendency for the usual bristles to be little more developed than the numerous hairs. The hind tibiae are very hairy beneath, before and behind, and the mid tibiae approach the same condition. The frons is about $\frac{2}{3}$rds or $\frac{3}{5}$ths of eye-width and in that respect it compares with *incisilobata*, but differs completely in its genitalia. The clasper (mesolobe) as seen from below is unusually wide at base and almost deltoid in outline, and also it is very hairy; the aedeagus, which in *incisilobata* is one of the most complicated in the genus, is in *hirticrus* very simple, ending in a slightly curved piece almost devoid of processes, a very small point only being visible inside the curve nearly at the end. The above characters should enable it to be separated from any other species.

S. falculata, Pand., has been taken or bred in some numbers since my paper was published; Mr. A. H. Hamm obtained it at Oxford, chiefly in fly traps at the Museum; Mr. J. Collins at Yarnton; and Dr. P. A. Buxton sent me a quantity from the London School of Hygiene, where it had come to bait on the roof of the building, and a number were caught and bred.

Blaesoxipha, Loew.

This genus was included in the key in my paper, although at that time I was unable to record a British species; but it seemed almost certain that it would occur here. Now already I am able to report capture of at least two species, *gladiatrix*, Pand., and *rossica*, Villen.

Blaesoxipha is really just a convenient "split off" from *Sarcophaga*, from which genus the species are not very obviously different, the characters given in the key, however, should enable them to be distinguished. The genital clasper or mesolobe of the male being split to the base, gives the appearance of a pair of structures, whereas in *Sarcophaga* it is usually only divided for a short distance down from the tip and is obviously a single organ. The presence of an external ovipositor in the female makes the identification of that sex comparatively easy, although sometimes it projects but a little way and requires careful observation for detection. In form it is like a horny spike, and in a few cases is long, projecting considerably and curved sicklewise. As secondary characters which may be helpful can be mentioned the presence of praesutural intra alars, and long strong praesutural acrostichals in *Blaesoxipha* which are usually absent in *Sarcophaga*, although a few species of the latter genus do show the acrostichals. They, however, tend to be less developed, shorter and weaker.

Our two species can be separated at a glance, *rossica* having red genital segments, and *gladiatrix* black ones. *B. rossica* indeed is distinguished from all other British Sarcophagines from the fact that both genital segments are wholly red: other red-tailed species having only the 2nd one so coloured. *B. rossica*, however, has one very near ally, *erythrura*, Mg., which also has both genital segments red, and which seems to be a better known and more widely distributed species than *rossica*, and which is so like *rossica* that very great care will be needed to be sure to which of the two any fresh captures may belong. The name *erythrura* was included in Verrall's List in italics under *Sarcophaga*, but I cannot find upon what authority, and it may or may not have referred to our species *rossica*. It seems desirable to look out for the possibility of true *erythrura* occurring here; Villeneuve, who described *rossica*, separated it from *erythrura* almost entirely upon the strength of differences in the male genitalia, which are difficult to describe. The most easily found difference is, I think, in the form of the clasper. If this is looked at from above it will be seen that in *erythrura* the inner upper edges, that is to say the edges on each side of the cleft, run perfectly smoothly in a regular curve right to the end; in *rossica* there is a distinct "kink" or bend about the middle and just beyond it obvious swellings on the outside, these swellings being covered with tiny bristles. Then, if the aedeagus is looked at from the same angle, in *erythrura* it will be found to terminate in a distinct fork, but otherwise without processes. In *rossica* there may be a suggestion of the beginning of such a fork, but it is very slight, and there are some small processes curving under which, however, it is difficult to see. Baranoff (32) has mentioned some minor differences in external details, but in a good series of *rossica* which I possess I find that they are not to be depended upon. In particular in a key he distinguishes the two species by the number of strong bristles on the outside of the fore tibiae which he says are three in *erythrura*, two only in *rossica*, but my *rossica*, whilst varying a little, mostly seem to possess three distinct bristles. I may add that Dr. Villeneuve very kindly examined one of our specimens, and I have his authority for its correct identification with his *rossica*.

Amongst 50 specimens taken by Mr. Collin and myself are only two females, and this sex seems generally to be less known than the male. It seems doubtful if the two species in question can be separated in this sex, but as Dr. Villeneuve only knew the male when he described the species some particulars may be advisable. The ovipositor emerges from an arched opening at the end of the abdomen and seems to me to be a development of the sternites: it and the apical abdominal segment are reddish; it is horny, and in form is like a long narrow pointed plate, with the edges turned upwards so as to form a channel, a semitubular piece, and then the whole thing is bent downwards in a sharp curve so that the point is turned under the tip of the abdomen, the channel being on the outside of the curve. It is not a large organ, its total length equalling only about ¼ as much again as the width of the arch from which it springs. Beyond the ordinary sexual differences—the frons is about of eye-width—the ♀ agrees with the ♂ in most respects. In the ♂ the abdominal markings are more fixed than is the rule in *Sarcophaga*, forming three fairly distinct rows of dentate markings; in the ♀ these seem less distinct and to vary more according to the point of view.

The first British specimen of this species was taken by Mr. J. E. Collin on Farley Down, Hants, on August 1st, 1930, and not recognised at the time. In 1931 Mr. Collin and I paid another visit to Farley, and one of our objects was to obtain more of this species if possible. When at last its habits were discovered, and it was to Mr. Collin that the credit of discovery is due, we found it to be present in some abundance and we obtained over 50 specimens between us, although as above stated only two were females. It was difficult to catch, sitting on stones on the barer portions of the Down and flying away as our net descended. We never saw one on a flower or anywhere excepting on these stones.

B. gladiatrix, Pand., as already stated, is easily distinguished from *rossica* by its dark genital segments: it is, however, also very difficult to distinguish from its nearest allies *grylloctona*, Loew., *cochlearis*, Pand., etc., which may also be found here, and it will be necessary for the male genitalia to be examined to be certain. In *gladiatrix* the forceps are long, thin, curved and distinctly hooked at the tip; the aedeagus also is long and thin, with the apical section widened but not greatly so, and with a slight simple finger-like process at the tip. The abdominal markings consist of the three rows of spots characteristic of the genus, but they are much reduced in size and obscured by the blue-grey tomentum. Col. C. G. Nurse took a male specimen in August 1926 in the Bournemouth District, which I saw in 1928 and identified as being a *Blaesoxipha* and probably this species, but the genitalia were not visible, and as it was a unique specimen and not mine I did not care to risk its destruction by trying to relax it to draw the parts out; it was the first certain British *Blaesoxipha*, but owing to the doubt about the species could not be recorded and I am still uncertain. On August 2nd, 1930, Mr. Collin took a single specimen at Matley Bog, New Forest (by curious chance, the day following the capture of the first *rossica*), and as its genitalia were pulled out I was able to satisfy myself that it was really *gladiatrix*. To make doubly sure it was submitted to Dr. Villeneuve, who knows the genus better than any one else, and its identification confirmed. Unfortunately again the importance of the capture was not recognised at the time and when we visited the locality again in 1931 in search of it, the weather was too unfavourable.

On August 4th last year we paid a visit to Chobham Ridges in Surrey in search of other things, and again amongst Mr. Collin's unrecognised captures were two *Blaesoxipha*. These, however, were females and so more difficult to distinguish, but I again considered them to belong to this species and Dr. Villeneuve without being able to feel certain is inclined to agree. They are very small, much smaller than either of the males or indeed than any *Blaesoxipha* in my collection, but size, as in the case of most TACHINIDAE, may mean nothing. The ovipositor is not to be seen at first sight as it barely if at all projects beyond the tip of the abdomen, but it is to be found by looking underneath, lying in a kind of groove into which it fits, a long narrow groove which permits the whole length of the organ to be seen; it is tapered to a sharp point, the channelled side being inwards and therefore hidden. The whole insect is covered with pale ashy-grey tomentum, making it look very grey compared with the blacker looking males, and the abdominal markings although still bearing the three longitudinal rows of spots, yet only show them when the abdomen is viewed from behind and then they seem slight and somewhat obscure. Even the legs are notably covered with the pale tomentum. The frons is barely of eye-width; antennae and palpi quite black and 3rd joint of antennae about half as long again as 2nd; *cochlearis*, Pand., with which I have been able to compare it, is a blacker looking insect, with markings well developed, and the ovipositor distinctly projecting beyond the tip, straight out and hollowed "scoop like." Unless or until we can get males to match these females their definite identification must remain uncertain, but I incline to regard them as *gladiatrix*, Pand.

Angioneurilla, Villen.

[*Angioneura*, B. & B.]

Amongst some specimens sent to me for identification by Mr. J. Collins I found a single male specimen of *Angioneurilla cyrtoneurina*, Zett., taken at Horning, Norfolk, on August 27th, 1928. This is a very small species nearly allied to *Morinia nana*, Mg., and very closely resembling that species, with which it may easily be confused; and amongst our British TACHINIDAE it is the only species with which it need be compared. Like *Morinia* this genus is characterised by the 4th longitudinal vein curving forwards to the 3rd only slightly and with a flat rounded bend, thus lacking one of the chief characteristics of the TACHINIDAE and in this respect more nearly approaching the ANTHOMYIIDAE. The two species may be readily separated by the following distinctions :—

Male with wide frons, at the vertex about equal to ⅔rds of width of one eye as seen from above; one orbital bristle on each side; in both sexes, arista almost bare; genae quite bare; 3rd segment of the abdomen bearing small discals . . . . *cyrtoneurina*, Zett.

Male with eyes closely approximated leaving a very narrow frons; no orbital setae; in both sexes, arista plumose, with rather long hairs; genae with some fine hair-like setae, which, however, may easily be overlooked; 3rd segment with no discals . . . . *nana*, Mg.

Villeneuve created the genus *Angioneurilla* for this species, characterising it by the wide frons with orbitals in the male, and by restricted thoracal squamae.

In my key it should run down to *Morinia* at 174.

In 1929 Mr. J. E. Collin and I were at Horning in August and captured many *Morinia nana* hoping to find this new species amongst them, but without success.

Mr. J. Collins has already recorded his capture in 1929, *Ent. Mon. Mag.*, **65** : 19.

(In 1932 Mr. J. E. Collin took a single specimen during a chance visit to Horning on August 14th.)

Pachyophthalmus, B. & B.

Mr. O. W. Richards found *P. signatus*, Mg., in his garden at Iver, Bucks, in 1929, and has already published an account in 1929, *Ent. Mon. Mag.*, **65** : 176-7. As Mr. Richards pointed out the genus would run in my key to sections 181 or 182, where it would have to be compared with *Sphecapata*, from which it can be distinguished as follows :—

Frontalia black, narrower than the front orbita; genae narrow, about same width as antennae; thorax strongly marked with three lines; abdomen with 1st segment nearly all black, the 2nd and 3rd each with three conspicuous dentiform spots; colouring throughout blackish grey *Pachyophthalmus*.

Frontalia rufous or pale, wider than a single orbit; genae wide, about double the width of antennae; thorax with indistinct markings only; abdomen with 1st segment pollinose, and with triple spots as on the 2nd and 3rd; colouring throughout a yellowish grey . . . . *Sphecapata*.

It might run to 158 in the key, but would be distinguished from *Ptychoneura*, with which it would have to be compared as follows :—

Arista thickened only at the base; 3rd joint of antennae only about twice as long as the 2nd; frontalia black; trilineate thorax, etc. *Pachyophthalmus*.

Arista thickened almost to the tip; 3rd joint of antennae three or more times longer than the 2nd; frontalia reddish; thorax with four dark lines, etc. *Ptychoneura*.

Mr. Richards' article in the *Ent. Mon. Mag.* can be referred to for further particulars regarding its occurrence and parasitic habits.

Pollenia, R.-D.

Many species have at different times been named in this genus, but most of them have ultimately been sunk as synonyms of one or other of the common ones. Recently, however, Mr. J. E. Collin sent me three pairs of what seems to agree with *varia* (Mg.), Stein, and to be a good species, taken by him at Wood Ditton Wood, Suffolk. I had made a note in 1927 when looking through his collection, that there were some small Pollenias which I thought might be this species, but without examination of the genitalia, which were not visible, it remained doubtful whether they might not really be just small *rudis*. The three males Mr. Collin so kindly sent me had fortunately had the claspers drawn out and I was able to compare them with *rudis* and satisfy myself that it was a good species; but I am not quite so sure that it is really the insect which Meigen named *varia*; nor am I quite sure that Stein's and Séguy's *varia* refer to the same thing, as none of the characters quoted by them seem quite dependable and the genitalia afford the only sure test.

In the meantime I am using the name *varia* and describing its characters so far as I have been able to determine them. It is definitely a smaller species than *rudis*, although small specimens of that species do occur which are no larger; *varia*, however, is consistently small and only 6 mm. long, so that size alone should lead to the discovery of the species, although it cannot be relied upon for its determination. The chaetotaxy is reduced: on the edge of the scutellum are only three pairs of strong setae instead of the four of *rudis*, the second from the thorax being inconspicuous; the 2nd pair of postsutural acrostichals is reduced or fails altogether. Stein says there are two pairs *at most*, but some of mine have the middle pair although thinner and shorter. Small *rudis*, however, tend to have the same setae reduced so that the character is not dependable. There seems a difference in the abdominal markings: in *rudis* the whole abdomen is covered with a shimmering grey tomentum which changes colour according to position; in *varia* the grey is more fixed, the first segment almost wholly dark as seen from behind, and the 2nd and 3rd showing a fixed central dark line or spot, widening out behind. Stein says that the apical sternite (" bauchlamellen ") is densely hairy, which he says is never the case with *rudis*; but although the hairs seem longer and rather more conspicuous in our *varia*, I cannot see much difference, and they are also to be found in *rudis*, and I don't think the character of much use; also he says that the apical cell is closed in *varia*, but it is not in any of ours. The genital claspers are, however, effectively distinct. If drawn out and looked at from the side, in profile, it will be seen that the paralobes, or outer pair, are nearly straight, thick, and parallel-sided in *rudis*, terminating in a rounded end; whilst in *varia* they are much thinner and strongly curved inwards. The central clasper or mesolobe in *rudis* is wedge-shaped, regularly tapered from base to point, keeled, with the flanges of the keel flat and ungrooved. In *varia* it is not so tapered, but is narrower than in *rudis* at the base, nearly parallel-sided for about half its length and then slightly widened before tapering to the point. It is also keeled, but there is a marked groove on each flange in the apical portion.

Besides Mr. Collin's Wood Ditton specimens, I have ♀♀ which I believe belong to the species from Bournemouth and St. Ives, and as Stein says it is common in Germany mixed with *rudis*, it will probably prove to be a common species here when once recognised.

Calliphora, R.-D.

In the course of examination of some Greenland CALLIPHORINAE sent to him for determination the attention of Mr. J. E. Collin was directed to an old headless male in his own collection, taken by Mr. G. H. Verrall at Tongue in Sutherlandshire many years ago, which from the genitalia alone he was able to identify with one of the Northern species *uralensis*, Villen., which he had found in the Greenland lot. Since then further specimens have turned up amongst some insects from St. Kilda, both in his own collection and that of the British Museum.

This makes four British species in this genus, which can probably be easily recognised from the following key :—

1. 2nd sternite definitely longer than wide, nearly half as long again; buccae either red or, if dark, at least with some red hairs . . . . 2.
   2nd sternite nearly square, width practically equal to length; buccae all dark, and all the hairs also dark . . . . 3.
2. Buccae red, clothed with all black hairs; genitalia with the side claspers or paralobes wide, not more than 6 times as long as wide *erythrocephala*, Mg.
   Buccae black, with many rufous hairs at least in the lower part; genitalia with side claspers long, thin and somewhat curved inwards, many times longer than wide . . . . *vomitoria*, L.
3. Thorax almost evenly covered with bluish tomentum, with slight traces only of dark lines; genitalia long and thin as in *vomitoria*, but straight, with little appearance of hairiness . . . . *uralensis*, Villen.
   Thorax bearing dark linear markings, seen from behind there is obvious in particular a conspicuous central stripe; genitalia long wedge-shaped, wider than in the other species at the base and tapered regularly to a point, bearing conspicuous long hairs especially on the inner side *germanorum*, Villen.

C. uralensis has a rather wider frons than *germanorum*, with frontalia fully as wide as orbits, whilst the frontalia of *germanorum* is reduced to a very fine streak at the narrow part; in *uralensis* the 2nd sternite seems a shade longer than wide, and in *germanorum* a shade wider than long. Dr. Villeneuve has kindly compared examples, of both *germanorum* and *uralensis* with his types and reports that they agree fully.

Acrophaga, B. & B.

The fact that *germanorum*, Villen., and *uralensis*, Villen., tend to form connecting links between *Calliphora* and *Acrophaga* at one time made me hesitate about the distinctness of the two genera, but I am now inclined to regard *alpina*, Zett., as being sufficiently different to justify the retention of *Acrophaga* as a separate genus for the present. It is chiefly characterised by the very wide sternites and enlarged genitalia. In *germanorum*, which has the sternites wider in proportion to length than any of our four British species of *Calliphora*, the 2nd one is nearly square, possibly a shade wider than long; in our *Acrophaga* it is about $\frac{2}{3}$rds as wide again as it is long, and the 3rd and 4th each in their degree are similarly different. The 5th sternite is very greatly developed and prominent, unlike anything known to me in the genus *Calliphora*; it is as long as the first three sternites put together, and projects outwards so as to be very conspicuous, and the genital segments are enlarged and produced in sympathy.

The above distinctions of course serve only for the males, and the females of *alpina* and *germanorum* happen to be so like one another as to be easily confused; they can, however, be separated as follows :—

Apical tergite with fine hairs only on the disc; squamae blackish *germanorum*, Villen.
Apical tergite with strong well-developed discal and marginal macrochaetae; squamae whitish . . . . *alpina*, Zett.

In the light of further information I feel that the two Logie females, which I formerly recorded as *germanorum*, need re-examination.

Throughout the above notes I have continued to use the name *alpina*, Zett., for our species, but from a paper recently published by Ringdahl (34) it seems that it is not the true *alpina* according to Zetterstedt's type, and should now be called by Ringdahl's new name *subalpina*.

After the MS. was finished and had been sent in, Mr. J. E. Collin very generously offered to make a set of drawings to illustrate some of the more important genital characters to which reference is made, and as a consequence the excellent figures that accompany the paper have been prepared, greatly enhancing its value. I am very grateful to Mr. Collin for his kind help.

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ERRATA.

p. 103, line 1, for "*styriacah*" read "*styriaca.*"
p. 136, line 12, for "*I. haitensis*" read "*T. haitensis.*"

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